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SPECIAL ISSUE ON THE BIOLOGICAL SCIENCES

CAPT Thomas B. Owen Appointed Chief of Naval Research

President Lyndon B. Johnson recently approved the appointment of CAPT Thomas B. Owen as Chief of Naval Research and nominated him for promotion to rear admiral. The appointment will be effective June 30. CAPT Owen will succeed RADM John K. Leydon.

CAPT Owen has been Director of the Naval Research Laboratory since January 1965. He received his B.S. in Chemical Engineering (cum laude) from the University of Washington in 1940; attended the U.S. Naval Postgraduate School for graduate study in electronic engineering from 1946 to 1947; was awarded a Ph.D. in Chemistry in 1950 from Cornell University under the Navy Advanced Science program; attended the University of Amsterdam, Netherlands, for Postdoctoral work from 1950-1951; completed a resident course at the Industrial College of the Armed Forces at Fort McNair in 1962; and completed the Advanced Management Program at Harvard Graduate School of Business Administration in 1964.

He received the Silver Star medal for action in the Battle of Tassafaronga. His ship, the heavy cruiser USS NORTHAMPTON, was sunk in the battle. Some two years later, another ship he was serving on, the destroyer USS BUSH, was sunk in a kamikaze attack off Okinawa.

Before being appointed Director of NRL, CAPT Owen served as NRL's Director of Support Services. Other assignments include temporary duty with the Assistant Secretary of the Navy for Research and Development, duty with the Office of Naval Research, the Long Beach Naval Shipyard, the Bureau of Ships, and serving as military assistant to the Deputy Director of Defense Research and Engineering.

In addition to the Silver Star, CAPT Owen holds the Bronze Star, the Asiatic-Pacific Campaign Medal with 12 battle stars, the Philippine Liberation Medal with one star, the Navy Unit Commendation Ribbon, and others.

He is a member of the following societies: Sigma Xi, Tau Beta Pi, Phi Kappa Phi, Phi Lambda Upsilon, American Chemical Society, the Naval Institute, the Philosophical Society of Washington, American Management Association, and the American Association for the Advancement of Science.

CAPT Owen and his wife Rosemary have four children: Catherine, Thomas, Jr., James and Nancy.

Naval Research and the Biological Sciences

Roger D. Reid

Director, Biological Sciences Division
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Most of the Navy's contributions to science have been in the physical sciences, engineering, and technology. However, biology has not been overlooked. Indeed, the Navy's interest in biology is growing because of its increasing importance to naval operations. The objectives of ONR's research programs in the biological sciences therefore are to maintain men in the best possible condition to perform their missions, to prevent machines and equipment from becoming inoperative through activities of biological systems, and to learn how various biological systems can be utilized to help solve Navy problems.

Specifically, research is supported by ONR to provide basic information that will be useful in:

- prevention and repair of injury to personnel;
- physiological reactions to military stresses;
- host-parasite relationships and the control of mission-related disease;
- diagnosis and treatment of disease and pathological states encountered in military personnel; and
- environmental biology including investigations of the relationships between components of various environments; biochemical and biophysical properties of environments and their effects on life; actions and reactions of and energy transformations by biological systems; and the effects of marine organisms on men, ships, weapons, and equipment.

The Office of Naval Research is composed of six basic research divisions and three supporting groups. The resultant academic mingling of the sciences is extremely useful in anticipating problems of the operational Navy. The Biological Sciences Division covers four areas: physiology, biochemistry, microbiology, and medicine and dentistry. This grouping is rather arbitrary and there is much overlapping of scientific disciplines, a fact which has enhanced rather than hindered cross-fertilization and interdisciplinary approaches to research.

The Navy is unique in that it operates in all types of environments: in the air, on land, on the surface of the sea, and under the sea. Navy personnel who are exposed to extremes of temperature and pressure in all of these media are the focal point of all naval operations. To be sure that such operations are successful, therefore, men must be maintained at peak physiological efficiency.

ONR's approach to biological research is based not only on problems currently recognized, but also on problems that may develop in the future. Such work is complemented by, and is complementary to, the research and development performed by the various bureaus and commands of the Navy.

Cooperative studies between the Ships Systems Command and ONR have included such things as research on biological fuel cells, biological effects of radiation, fouling, and problems of ASW based on excitation of biological particles. The Facilities Engineering Command and ONR have mutual interests in biological deterioration and biological warfare detection and decontamination. The Air Systems Command, Bureau of Medicine and Surgery and the Office of Naval Research mutually share research on physiological effects of acceleration, anoxia, cockpit habitability, orientation and disorientation and other problems affecting men of the Navy air arm. The Ordnance and Air Systems Commands, deeply concerned with their potential role if the U.S. Navy is required to respond to biological and chemical warfare activity by an enemy, cooperate with ONR on basic research needed to meet this requirement.

The basic research program of ONR complements the clinically-oriented objectives of the R&D programs of BuMed. This cooperative effort has led to improved diagnostic and therapeutic methods for medical, surgical, and dental problems peculiar to the Navy.

Much basic research in the biological sciences is supported by other agencies such as the National Science Foundation and the National Institutes of Health. However, duplication in research sponsored by these agencies and that sponsored by ONR's Biological Sciences Division is minimal. The NSF is primarily interested in a wide variety of basic problems for their own sake while ONR has organized its research into Navy-relevant, mission-oriented programs. Much research supported by or done at NIH *is* useful to the Navy. However, there are many problems peculiar to the Navy in which NIH has no interest or unique capability.

The Navy has contributed considerably to knowledge required by the National Aeronautics and Space Administration in planning for manned space travel. Not only was the Navy a source of much basic physiological and other biological information in the beginning

of NASA operations, but many of our Navy laboratories are continuing to cooperate with NASA in space research.

Physiology

Naval personnel are exposed to both environmental and operational stresses that may impair their health and/or performance. Basic biological processes involved in regulating man's responses to stressful conditions imposed by non-ionizing radiation, acceleration, temperature and pressure extremes, and injury must be fully defined. This requires a thorough understanding of the physiological and biochemical responses to the stressful conditions involved.

Research is currently being conducted on the nature of fundamental physiological processes and on biological protective mechanisms against stress such as acclimatization to various environmental extremes. Such knowledge will help to insure that naval personnel can perform their missions with maximum efficiency while utilizing their equipment optimally. Special emphasis is being placed on problems of deep submergence and performance under high pressure. This involves investigations into the prevention of bends, inert gas narcosis, oxygen toxicity, excessive body heat loss, and similar operational problems.

A Sealab diver alongside submersible decompression chamber. The Navy is placing special emphasis on problems of deep submergence and performance under high pressure.

Microbiology

In order to best serve the Navy's mission, research in microbiology has been directed towards the support of four major areas. *Marine microbiology* is stressed in order to learn what transformations by microorganisms contribute to the cycling of important chemical elements in the oceans. Also, research is aimed at learning what dissimilatory processes of bacteria are indigenous to ocean depths, arctic waters and other special marine environments.

Investigations in *microbial genetics* will help us to understand the mechanisms which control microbial biosynthesis, cell multiplication, and antigenic specificity. Results from studies in this area will help Navy scientists to improve the efficacy of vaccines and to control diseases caused by bacteria, viruses, and other microorganisms.

To help solve problems of disease prevention, treatment, and cure, a program of research on *host-parasite relationships* has been conducted for many years. This program includes research on bacillary dysentary, influenza, meningococcic meningitis and other diseases of special interest to the Navy. Such studies should lead to better control and optimization of natural human defense mechanisms. It is concerned with studies of interrelationships between viruses, between viruses and bacteria and between pathogenic microorganisms and their susceptible animal or human hosts. The host-parasite relationships program has contributed much to epidemiological studies within the closed environments of submarines and within the controlled populations of recruit camps.

The threat of *biological warfare* to which Naval personnel may be exposed makes it necessary to develop methods for the rapid detection and identification of and protection against potential BW agents. Research in aerobiology under ONR management at the Naval Biological Laboratory, Oakland has contributed a great deal to the understanding of the behavior and survival of microorganisms in aerosol form.

Medicine and Dentistry

Medical treatment of large numbers of casualties in a short time demands ready access to a large supply of transfusable blood. A blood preservation program directed toward military field shipboard use of blood is being carried out to implement the work of the Naval Blood Research Laboratory at the Naval Hospital at Chelsea, Massachusetts. Emphasis in this research is directed toward the study of the mechanisms of cell function by techniques recently developed in fields of molecular biology and cellular biophysics.

Research on the management of military trauma and on the treatment of severe burns is concerned with tissue transplantation. Cryobiologic principles are being employed to develop methods for conservation of tissues in the living state in order to maintain banks of transplantable skin, bones, and perhaps, eventually, organs. Also, because of incapacitation of Navy personnel due to dental diseases, particularly under stressful operational conditions, a research program in oral and dental health is being supported in conjunction with the Dental Division of the Bureau of Medicine and Surgery.

Bone graft procedures involving restoration of maxillo-facial defects with cryobiologically preserved homografts and autogenous bone marrow

Biochemistry

Much of the knowledge needed to deal with naval biomedical problems will derive from studies of primary use to the general public. There are, however, human hazards of special concern to the Navy, and there may be factors in the naval situation which can be used to advantage if understood. Hence, association with basic studies of metabolism, as these apply to particular diseases, trauma, and life forms important in naval operations must be retained.

The field of *immunochemistry* is being explored to better understand the nature of serological specificity. This will contribute to a capability for providing broad-spectrum immunization as a protection against classes of infectious agents, rather than specific ones, both for epidemiological reasons and for coping with the threat of biological warfare. Serological reactions also offer promise for the development of rapid

and accurate detection methods for biological warfare. It will also lead to advancements in the technology of tissue and organ transplantation needed for treatment of military casualties.

Efforts are being made to establish basic principles of *toxicology* which may anticipate hazards, rather than dealing with hazards which have already been recognized. Thus, investigations are being made of physiological actions of substances which do not lead to clinical symptoms under normal conditions, but which may do so on chronic exposure, *e.g.*, minimal levels of carbon monoxide, or under the conditions of pressure or exotic atmospheres such as helium.

Biology in the Oceans

Studies which may explain life processes of particular interest to the Navy can serve to provide the basis for applied research leading to the purposeful control or imitation of life processes or to forecasting the influence of the biological elements in fields of naval operations.

The Navy should know how marine life differs from analogous non-aquatic life. For example, simple ancestral forms of life in the sea may give new insight into the metabolism of more highly evolved forms on land or in the air. Understanding a wider variety of life forms may similarly serve to improve our comprehension of *all* life processes.

Biological activity in the marine environment can be useful or harmful. ONR research is designed to exploit the useful and control the harmful activities of the wide variety of living forms. Studies include problems of distribution, seasonal fluctuations, behavioral patterns, nature and biochemical properties of marine plants and animals as they relate to naval operations. This research is augmented and intensified by basic biological investigations of terrestrial forms. A delicate balance is maintained between research on life processes and the potential effects of biological forms on the oceans and on naval operations.

Research on biological orientation and communication will provide a better understanding of how animals communicate and navigate. In addition to the basic information which may aid in the control and utilization of animal life, it may possibly lead to naval application in the development of improved military guidance systems.

Research in ecology provides insights into adaptations of plants and animals to their environments, especially their ability to survive under adverse conditions. Basic studies on physiology, biochemistry, nutrition, metabolism, defense mechanisms, and the like are required to understand how living systems can be controlled and utilized in military operations. Also included are studies in toxinology which deal with poisonous and venomous animals of the environments in which naval personnel may operate.

The articles that follow describe the ONR programs in greater detail.

Objectives of Program Subelements in the Biological Sciences Division

Regulatory Mechanisms: This program attempts to obtain insights into fundamental characteristics of individual systems regulating life processes in order to understand the complexity of responses under ordinary conditions as a basis for understanding unusual operational or environmental stress responses. It involves endocrine system response and stimulation of other organs by means of hormones and nervous system interaction, and includes compensating mechanisms exhibited by the respiratory, circulatory, excretory and thermoregulatory systems.

Dr. Roger D. Reid

Biological Response to Environment: Navy and Marine Corps personnel must be protected from the physiological hazards accompanying various operational and environmental conditions to ensure their performance at peak effectiveness. A basic program on the physiological responses to high and low pressure, climatic pressure, acceleration effects, non-ionizing radiation, and fatigue is being undertaken. Major emphasis is being placed on the high pressure, underwater environmental effects.

Biochemistry: A complete knowledge of life processes is essential to thorough readiness for naval action, in order to control or possibly imitate useful aspects of natural events and to avoid limitations imposed by natural or artificially introduced living elements in the operational environment. In the final analysis, such knowledge must be expressed in terms of metabolism and catabolism, biosynthesis and other aspects of biochemistry.

Immunology and Hematology: The phenomenon of immunological specificity is a factor in immunization against many biological hazards and also underlies the development of others, such as allergies and rheumatic fever. The phenomenon constitutes a technological barrier to the full use of medical capabilities for treatment by tissue

transplantation and transfusion. It also can be made useful through the serological methods for identification and classification of organisms and materials of biological origin. The objective of this program subelement is, therefore, the ultimate understanding of the biochemical basis for individuality in the immunological sense.

Chemical Countermeasures: This project is subdivided into toxicology and toxinology. In the first, the objective is to provide the knowledge needed to deal with chronic exposures to slightly toxic materials within self-contained living and working quarters, with toxic materials generated by naval operations, and with the pharmacological effects of toxic materials and drugs under the peculiar environmental conditions imposed by operations carried out in intimate contact with seawater at considerable depths. The second seeks to establish the nature and properties of natural toxins produced by marine organisms and other creatures encountered in naval operations with the ultimate purpose of providing logical and effective protection, therapy, and utilization of these products.

Host-Parasite Relationships: Research in this area explores the interrelationship between a microbial parasite and its living host. The parasites concerned are protozoa, yeasts, fungi, bacteria, viruses, rickettsia, mycoplasma, L-forms, or hitherto undescribed microscopic forms of life. The hosts are animal and plant tissue cells cultured *in vitro,* intact animals or humans, or other cells susceptible to invasion by infectious agents. Those factors which enhance or impede the infectious process or affect the susceptibility or resistance of the host are of special interest. Antigenic components or products of metabolism of infectious agents will be subjected to investigation, as will all possible defensive mechanisms of the host.

Marine Microbiology: It is important for the Navy to know the nature of chemical transformations brought about by microorganisms which contribute to cycling of oxygen, carbon, nitrogen, phosphorus, sulfur, and trace metals in the marine environment. Studies will establish which microorganisms are responsible, and under what specific conditions, for the initiation and/or catalyzation of fouling, corrosion, or any other form of biodeterioration in the marine ecology. Some investigations will be made to establish the importance of marine microorganisms as causative agents of diseases of marine mammals and the significance of algal polysaccharides in reducing drag and improving hydrodynamic efficiency of underwater vehicles.

Detection and Identification: Effort in the area of rapid detection and identification of disease-producing biological agents reflects a

continuing search for new concepts and approaches to this problem area. Exploration of current concepts and their associated procedures and equipment proceeds concurrently. Present concepts and approaches as interim solutions are complex and costly and in some cases inadequate for Navy and Marine Corps use.

Protection and Decontamination: Basic research on protection and decontamination, including cell structure and metabolic functions of microorganisms, in conjunction with studies of serologic and immunologic phenomena, will form the basis for the production of new and improved vaccines against microbial agents of potential use against naval forces in biological warfare. Information derived from these studies will permit estimates to be made of the effectiveness of these agents in producing disease and will characterize the physiological responses they induce. This work will include investigation of the possibility of a potential enemy artificially altering the host specificity and behavior of an agent with the objective of making its identity and preempting defensive countermeasures. Studies on toxic substances produced by microorganisms should aid in the clarification of the modes of action of disease agents and methods of neutralizing their effects.

Aerobiology and Epidemiology: This research in aerobiology and epidemiology is designed to determine the effects of physical, chemical, and biological factors on the production, behavior, stability, movement-dispersion, and decay of biological organisms in an aerosolized state. It includes studies on the role of infectious agents in the epidemiology of diseases of significance to Navy-Marine forces. Such information offers the potential of immediate military application. For instance, studies to date indicate that rapid and pronounced shifts in relative humidity produce significant reduction in the number of viable aerosolized microorganisms. Thus, a concept of decontamination of enclosed spaces without resort to materials toxic to man or deleterious to materials is envisaged with respect to certain microorganisms.

Biophysics: This project utilizes techniques developed in the field of biophysics to obtain basic information applicable to biological problems such as the preservation of blood and other tissues. It includes studies on biochemical and biophysical interactions of normal and diseased tissues, energy exchange mechanisms in living cells, radiobiology of certain cell systems, biological effects of ionizing radiation peculiar to naval environment and the development of cryogenic instrumentation.

Biological Orientation: This program is to obtain engineering information through analysis of sensory and integrative components of animals

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that exhibit orientation capability. It provides for a wide range of studies on the mechanisms involved, including investigations of the reception and transmission of information stimuli and of the responses to such stimuli. It employs engineering methods, physical techniques and mathematical analyses—with emphasis on telemetry as a means of detecting biological activity and of investigating mechanisms by the design of experimental analogues.

Cellular Biology: The research sponsored under this program is designed to provide information that will reduce time required to restore casualties to duty. It is directed to the elucidation at a cellular, subcellular, and molecular level of the mechanisms involved in metabolic disease and cell and tissue regeneration. Studies of cell specialization and functional control mechanisms are concerned with immune tolerance to homografts, a problem in surgical repair, and with cellular processes operating in traumatic and shock states. The interactions of normal and diseased oral tissues are being investigated in an effort to achieve rapid, safe, and effective induction of resistance to dental disease in personnel employed in environments where professional care is not available.

Naval Ship Research and Development Center Established

Vice Admiral I. J. Galantin, USN, Chief of Naval Material, announced that, effective March 31, 1967, the David Taylor Model Basin, Carderock, Maryland, and the Navy Marine Engineering Laboratory, Annapolis, Maryland, consolidated to form the Naval Ship Research and Development Center.

The consolidation of these two activities results in a more economical and efficient operation in the entire area of ship research and development. For the first time, the Navy has a research and development center with the capabilities and expertise to attack ship structural and propulsion technical development concepts on a total ship basis. The new Naval Ship Research and Development Center provides the framework for building on existing capabilities to ensure complete and thorough coverage of all disciplines related to the whole ship as a vehicle, and will perform research, development, test and evaluation work in hydrodynamics, structural mechanics, aerodynamics, acoustics, vibrations, mathematical analysis and computer techniques, and marine engineering. The Center will benefit not only the Navy but the entire maritime industry as well, and portends a future for coordinated ship concept research and development programs which has never before been possible.

The Commanding Officer and Director of the Center is Captain Manuel da Costa Vincent, USN, who will operate out of Center Headquarters at Carderock, Maryland. The Annapolis Division is headed by Commander J. D. Evans, USN, as Officer-in-Charge. Dr. Alan Powell is the Technical Director of the new Center.

Physiological Research at ONR

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The Navy realizes that one of the surest ways to break down the operating effectiveness of its personnel is to expose them to stress conditions against which they are inadequately protected. And, since the Navy and Marine Corps are called upon to function in all sorts of *milieux*—deserts, mountains, tropics, polar regions, in the air, in or on the ocean, *etc.*, they encounter a variety of physiological stresses. To insure that these men are offered the maximum protection against these stresses, the Navy conducts a considerable research program into these problems, both through its intramural laboratories and through its contract research program which is administered by the Physiology Branch of the Office of Naval Research.

The ONR philosophy is to support basic investigations in those scientific areas most likely to shed light on the mechanisms underlying the physiological stresses encountered by service personnel. This so-called "mission-oriented" basic research concept has led to the evolution of a contract research program that is closely coupled with the goals of the intramural laboratories. At the same time, this program is seeking new research pathways that might prove fruitful in attaining those goals. Since research support must be secondary to operating the Navy and Marine Corps at peak battle effectiveness, the funds available for research are necessarily limited. Also, there are other federal, state and private agencies that support basic research. As a result, the ONR Physiology Branch program has restricted its areas of research support to those that can be of prime benefit to the Navy's operational needs.

Proposals are submitted to ONR by various academic, private or industrial laboratories on an unsolicited basis. After an independent review and evaluation for scientific merit by an outside group of scientific advisors, proposals are selected for support depending on their scientific merit, relevance to the Navy's program and the availability of funds. In order to have a meaningful impact on solving the operational physiological problems confronting the Navy, the Physiology Branch has selected four areas in which to concentrate its efforts. These areas are acclimatization to physiological stress, the physiology of fatigue, underwater physiology and regulatory systems involved in response to stress.

Acclimatization to Physiological Stress

A great deal of research has already been completed on the mechanisms involved in responding to the hot, arid climates of the deserts; the hot, wet climates of the tropical jungles; the dry, cold climates of the arctic; the dry, cold climates plus hypoxia of the mountains, *etc.* Survival in some of these environments requires elaborate protective devices and/or clothing. However, mere survival in a very hostile environment is not enough for today's military personnel. They may be called upon to operate effectively within minutes to hours after arriving in this environment, action which would involve the use of high level mental processes and complex weapons and equipment.

Natural acclimatization to a new environment requires anywhere from a week to several months, depending on the type and severity of the environment. By supporting basic research on new concepts dealing with body temperature regulation, new approaches may ultimately be developed to speed up the natural acclimatization processes. In this way, fresh troops arriving in hot, tropical regions from temperate ones would not have to go through the transitional, debilitating period while they become acclimatized. Analogously, properly acclimatized Marines could be airlifted from sea level conditions to areas high up in the mountains to seize and hold strategic mountain passes without the logistically burdensome use of supplementary oxygen supplies.

Fatigue

Fatigue is a physiological problem that affects all personnel regardless of rank or type of duty. It is a particularly difficult research area in which to work because of all the factors, either singly or in combinations, that might play roles in its onset. For example, the state of nutrition, the relative freedom from disease, the environmental conditions, and the mental set of the individual might all contribute to enhancement of or resistance to fatigue.

Much has been written about the value of psychic energizers, physical fitness, tonics, special food preparations, *etc.* in combating fatigue. Some of these are of partial or little value to normal military personnel. In some instances the side effects or after effects from some of these approaches may not be worth the temporary advantages obtained from their use.

The Physiology Branch program in this area is geared toward delineating the physiological and biochemical mechanisms underlying the development of the fatigue state. Years ago it was suggested that there are substances in the body which accumulate to produce a state of fatigue, but these hypotheses were never verified experimentally. Recent foreign studies have raised this question again and present an opportunity for isolating, purifying and chemically characterizing a possible fatigue substance or substances. Whether this can be accomplished and whether it can then be shown that this substance regulates the onset and/or decay of the fatigue state is of considerable interest. Positive findings would, of course, open the door to the preparation of synthetic anti-fatigue agents.

There are generally two views concerning the production of neuromuscular fatigue: control by local or peripheral factors or control by central nervous system factors. It would be of value to determine under what experimental conditions these controls might operate. It is conceivable that there might be a specific locus in the sensory motor chain which becomes unresponsive to repeated stimuli. The reason for this may be that repeated stimuli upset optimal signal/noise ratios in the brain, causing disruption of normal stimulus-response reactions.

Many of the fatigue research results and conclusions garnered from past experiments are considered equivocal because of inherent shortcomings in teasing out and distinguishing between the effects of physiological fatigue *per se* and the effects of such masking factors as monotony, learning, *etc.* To avoid ambiguous interpretations, experimental designs must take these factors into consideration. A heretofore little pursued topic of interest relates to the commonality of various fatiguing conditions. For example, it is possible that the fatigue prevalent during the early days of exposure to altitude is characterized physiologically

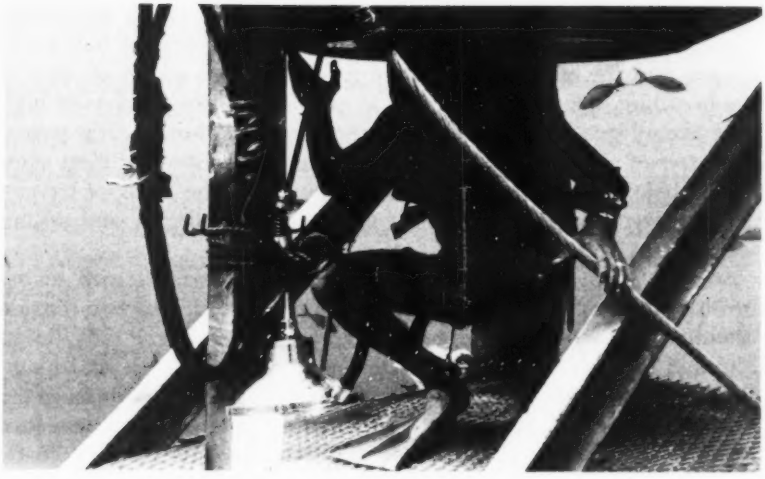
and/or biochemically in the same manner as the fatigue associated with exposure to high ambient pressures of underwater diving. These two diverse environmental conditions may trigger a common fatigue inducing mechanism.

Underwater Physiology

The problems currently receiving the greatest level of support from the Physiology Branch are those dealing with man's efforts to live and operate in an underwater environment. Historically, the Navy has had an interest in this area for many years and for very practical reasons. In operating within or on the ocean, various tasks developed such as submarine rescue, underwater construction and salvage which required men to do purposeful work under water. As early as 1912, the Navy had organized a school for training deep sea divers for salvage and rescue operations. When submarine hulls became capable of withstanding greater and greater hydrostatic pressures, it was necessary to increase the depth capability of Navy divers.

The chief disadvantage of deep diving is the penalty paid in the long decompression period required for the relatively short period of work on the bottom. For example, to raise the sunken submarine SQUALUS in 1939 from a depth of 240 feet required a total of 640

Navy deep sea divers wait decompression on diving stage during diver training



Sealab (saturation) diver leaving submersible decompression chamber prior to entering underwater laboratory

dives over a four-month period, each dive averaging 20 minutes of bottom time. Today's operational diving techniques have not changed much from those of 1939.

To circumvent this sort of situation, the concept of saturation diving was introduced to the Navy by CAPT George Bond, MC, USN and his associates. However, because of limited experiences with this technique, it has not yet been incorporated operationally. Its chief advantage stems from the fact that the body's tissues are, for all practical purposes, completely saturated with the gases of the breathing mixture within the first 24 hours of exposure at a given depth. No matter how long the diver remains at that depth thereafter, the necessary decompression time is constant. Nevertheless, the need for the capability for short term, deep dives with relatively short decompression schedules still exists. Certain tasks can be accomplished far more efficiently by a pair of short-term divers than by a team of saturation divers.

It should be noted that current Navy He/O_2 gas mixtures and decompression schedules would require several *days* for decompression following a saturation dive to the depths of the continental shelf (average 600 feet). On the other hand, a short-duration dive to that depth would require many *hours* for decompression after a bottom working time measured in minutes. One of the prime physiological research considerations is to reduce decompression time for both short-term and saturation diving to a minimum, consonant with safety. There are several possible research avenues that can be probed to gain that objective. One is to investigate such basic phenomena as the solubilities

of various gases in various tissues, the dynamics of gas solubilities caused by rapid changes in environment, the formation of bubbles in tissues, and the effects of switching from one inert gas to another in the breathing mixture. Another is to examine the toxic effects of high pressure oxygen in all of its ramifications to learn how greater partial pressures of oxygen could be used to hasten the washout of inert gases (the bubble formers) from tissues. This involves the study of oxygen at the enzyme level as well as at the cell, tissue, organ, and system levels.

Some of the other physiological problems associated with diving involve inert gas narcosis, increased work of breathing, carbon dioxide retention, body heat loss and bone necrosis. Much of the difficulty of nitrogen narcosis has been alleviated, in this country at least, by substituting helium for nitrogen in breathing gas mixtures. Aside from the loss of voice intelligibility and the increased rate of body heat loss, helium has worked well in the saturation dives undertaken to date. At a depth of about 900 feet on a short duration dive conducted by an European investigator, however, there was some indication that helium was slightly narcotic. What this might mean in terms of a saturation dive at equivalent or lesser depths has yet to be determined. There is, therefore, considerable interest in the physiology of inert gas narcosis and the role it might play in the performance decrement in a high pressure environment.

As man goes deeper and deeper into the sea, the density of the gases which he breathes becomes greater and, consequently, more difficult to move in and out of the lungs. This increasing density will eventually result in poor mixing of the oxygen contained in the inhaled gas with the high percentage of carbon dioxide retained in the lungs. As a result, the carbon dioxide will back up in the tissues, affecting the buffering systems of the blood and tissues. Also, the percentage of oxygen molecules under very high pressure will become very low, a fact which will affect the amount of oxygen diffusing across the lung tissue into the blood stream. In order to get enough oxygen to combine with hemoglobin under these high pressures, it might be necessary to use oxygen at a partial pressure that would normally be high enough to cause toxicity effects. Consequently, the problems associated with increased density of the breathing gas mixture under high pressure might well be the single factor most likely to limit man's depth penetration.

Other problems associated with living underwater stem from temperature effects. Helium has a much higher thermal conductivity than nitrogen, and water has an even higher one than helium. Water temperatures have been reported as low as 28°F in the arctic and ranging between 40° and 50°F off the coast of southern California in the summer. Consequently, an individual breathing a He/O_2 mixture swimming in

45°F water will experience an extraordinarily high rate of body heat loss unless some sort of protective garments can be developed both for the body and the extremities. The fingers and toes are extremely sensitive to cold since, because of their shape, there is a relatively large surface area per unit of tissue volume. Insulated gloves could be of value from a protective standpoint, but adequate insulation would make the gloves so bulky that finger dexterity would be lost. Furthermore, living in an underwater habitat requires a whole new set of criteria with respect to thermal comfort in an He/O_2 environment under various pressures and humidities. These criteria as well as the thermal efficiency of protective clothing will have to be determined before the full usefulness of man within the ocean can be realized.

Regulatory Systems

The ONR research program dealing with regulatory systems embraces aspects of neurophysiology, respiration, circulation, endocrinology and body temperature regulation.

In neurophysiology, we are particularly interested in cellular metabolism, transmission of the neural impulse and the integration of neural inputs by the central nervous system. These problem areas are of interest to the general scientific community, but are of special importance to the Navy from the standpoint of their involvement in various stressful conditions (*e.g.,* hypoxia at altitude or oxygen convulsions under pressure). Similarly, ONR supports some research into the basic mechanisms regulating the respiratory system. For example, extensive basic investigations into the interactions of the oxygen, carbon dioxide and relative acidity of the blood to control respiration have been supported.

Because of the important role that blood plays in the transport and exchange of gases, in rewarming and cooling the body, etc., a real interest exists in the characteristics of, and influences on, blood flowing through the vessels of normal beings. Consequently, ONR supports research in the physicochemical factors involved in determining blood flow in capillaries, the metabolism of blood vessels in the microcirculation, the role of the physiological state of the blood vessel wall on blood flow, *etc.*

The involvement of the endocrine system in the stress response has been known and studied for several years, but there are still new and important findings being revealed from time to time. Interest still exists in research on the role of the pituitary-thyroid-adrenal axis in stress reactions. Attention is being focused particularly on the chemical interactions of the hormones from these glands with other substances normally found in the body thst might be involved in acclimatization, fatigue, stress, and atmospheric pressure effects.

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The current research support in body temperature regulatory mechanisms is primarily concerned with the role that normally occurring biochemical agents play in regulating body temperature. At the present time, research is being conducted on epinephrine, norepinephrine, and serotonin (all normally found in the hypothalamus of the brain) effects on the central control of body temperature. If the body's temperature regulation is mediated by biochemical means, the hope for attaining rapid thermal acclimatization via a pharmacological agent may be closer to realization.

Conclusion

This has been a brief review of the salient features of the Navy's research program in physiology. It is not intended to exclude other research problems that might be of interest to the Physiology Branch now or at a later date. The only criteria that govern types of research performed under ONR contract are scientific merit, Navy relevance and availability of funds.

Dr. Alan Berman Selected as NRL's Director of Research

RADM J. K. Leydon, Chief of Naval Research has announced the selection of Dr. Alan Berman of Hudson Laboratories, Columbia University, New York, as Director of Research at the Naval Research Laboratory.

The 41-year-old Dr. Berman, a native of Brooklyn, New York, will fill the post left vacant last December by the retirement of Dr. Robert M. Page. He is scheduled to begin his new duties on June 1.

Currently Director of Hudson Laboratories, Dr. Berman, who is an expert in underwater acoustics, oceanography and signal processing, received his A.B. degree from Columbia College in 1947 and his Ph.D. degree from Columbia University in 1952.

Dr. Berman joined the staff of Hudson Laboratories in 1952 as a research scientist. He later served as assistant director and associate director before becoming Director in 1963. On three different occasions he served as a visiting scientist at Admiralty Research Laboratory in Teddington, England. For two months during 1960, he was a visiting scientist at Saclant ASW Research Center in La Spezia, Italy. He has published approximately 40 papers.

Research On Biomedical Problems

Arthur B. Callahan
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Some aspects of the research program of ONR's Medicine and Dentistry Branch are presented here in order to describe the program, the diversity of disciplines involved in the program and the steps taken to maximize our research efforts. From the point of view of scientific content, the program is heavily, although not totally, oriented toward two main areas: blood preservation and dental research.

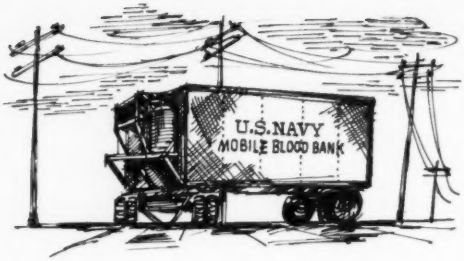
In any discussion of a research-program structure, it is necessary to establish overall as well as specific goals for the program. In this instance, the overall goals are that it should be Navy-oriented and should provide basic research supplements to on-going Navy research efforts.

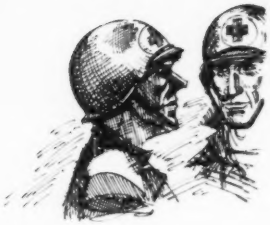
Blood Preservation

The specific goals of the blood preservation program are to uncover the mechanism of freeze-thaw damage to the red blood cell, and to explain the mechanism by which cryoprotective agents prevent damage to this cell.

ONR has supported the development of several methods which permit large-scale, long-term storage of frozen blood which can be rapidly prepared after storage for field and shipboard use. The basic research program of the Medicine and Dentistry Branch has been directed toward the assessment of the physical and chemical properties of the normal and preserved red blood cell in order to improve clinical acceptability.

The ability to preserve viable red blood cells for several years represents a significant advance when compared to the present blood bank storage period of 21 days. Such capabilities are of special significance in a warfare situation when a high demand for transfusible blood exists and when a stockpile of rare bloods is needed. The physiological effects of freezing, storage, and thawing on red blood cells, however, requires clarification. Specific emphasis is being given to the following areas: mechanism of action of cryoprotective substances; nature of the freeze-thaw lesion on the red blood cell membrane; comparative evaluation of several freeze-preservation methods with respect to percentage of recovery of red cells; survival times of red cells; and hemolysis after transfusion.





The area of cryoprotection offers many examples of cross-disciplinary efforts in basic research. There are several hypotheses that attempt to explain the mechanism by which cryoprotective agents act: (1) they prevent mechanical rupture of the cell through modification of ice-crystal growth; (2) they prevent electrolyte concentration within the cell, which would produce denaturation; (3) they prevent cell dehydration, which would permit precipitation of proteins from solution; and (4) they prevent abnormal cross-linkages in the cell. In all these hypotheses, structural water plays a vital role. Much more needs to be known regarding the residence of structural water in pores, in micelles, and on surfaces. Also, it is essential to learn how structural water protects active sites; how it forms easily reversible bonds between molecules, such as the lipid-protein complexes; and, perhaps, as Dr. Fernandez-Moran has suggested, how it participates in such "functional" processes as electron or proton transport information transmission.

The ONR program is addressed to the problem of structural water in the cell and the problems of bond interactions between water molecules and cryoprotective substances. This has entailed the use of such techniques as neutron inelastic scattering, dielectric spectroscopy and electron paramagnetic resonance for the study of crystal lattice structures. Interest in this area has required investigation in the physical chemistry of liquid-solid phase transitions in aqueous solutions, an area in which much basic research is essential. It is expected that such effort will eventually result in the availability of more effective and clinically acceptable cryoprotective agents for use in frozen-blood preservation.

For the past several years the Navy Blood Research Laboratory at Chelsea, Massachusetts has carried out extensive *in vitro* and *in vivo* evaluations of red cell preservation processes as well as extensive clinical evaluation studies. The results of this effort have led to a frozen blood feasibility study that is being carried out in Vietnam by the Bureau of Medicine and Surgery under the direction of Commander Charles Brodine, MC, USN.

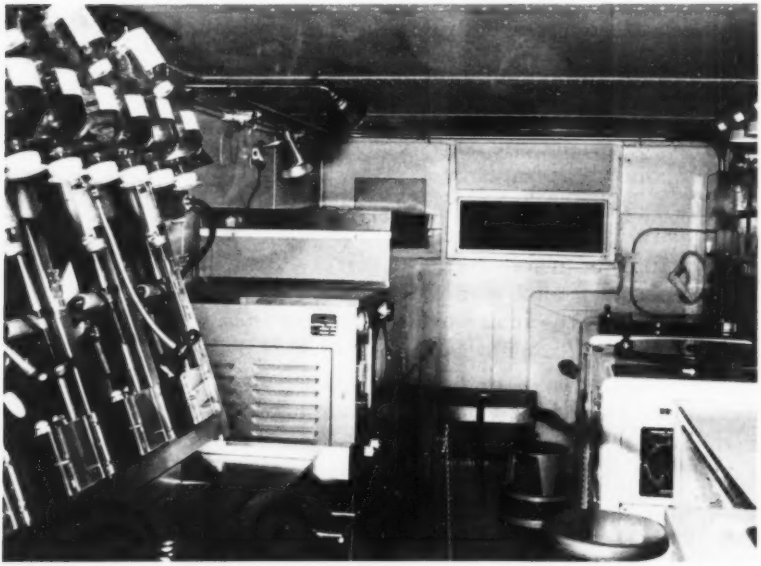
The objective of this study, in addition to evaluating the logistic problems concerned in supporting a frozen blood bank in a combat area and

determining the clinical acceptability, is to estimate the potential of a frozen blood bank system in supplementing the standard system.

Since the latter part of 1965, mobile trailers equipped with frozen blood bank units have been in use in Vietnam. One trailer, a processing van, contains the necessary equipment for thawing and reconstituting blood processed by a method developed by Dr. Charles Higgins of the Massachusetts General Hospital, Boston. It holds a cytoglomerator which is required for washing away the protective additive, glycerol, from frozen red cells; a low temperature freezer; two refrigerated centrifuges; and tables for needed working space. A larger van provides laboratory facilities needed to evaluate the use of both frozen and fresh blood in patients. Similar non-mobile units have been established on hospital ships.

Experience with the use of blood frozen in the continental United States and shipped to Vietnam has demonstrated that it is feasible to set up and operate frozen blood banks in combat areas. Present evidence indicates that the massively injured patient handles frozen blood cells in a thoroughly satisfactory fashion.

The blood preservation program, which was initiated by the Navy, is now of international scope. Collaborative studies are underway in the Royal Army Medical College in London; the Central Laboratory of the Netherlands Red Cross, Amsterdam; and in the laboratories of the French Army Center for Transfusion and Reanimation, Clarmant.



The processing van for thawing and reconstituting blood

Dental Research

Within a short period—about 25 years—dental science has obtained a position from which it may soon resolve the major health problems posed by oral disease. This posture has derived from research which has led to a better understanding of the causes, treatment and prevention of dental caries; periodontal disorders; massive injuries to jaw and face; and various oral lesions of soft tissues. Naval dental research, both in-house and ONR-sponsored, has taken a prominent role in this development.

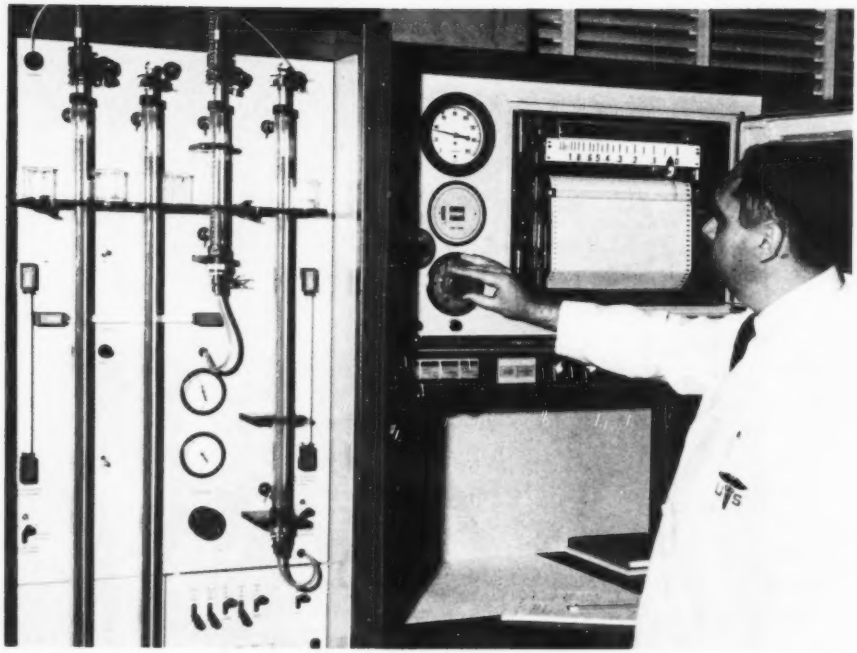
The rate of oral disease among Marine Corps and Navy personnel is greater, incrementally, than the manpower and resources available to treat it. Only research and prevention can lessen the burden—a fact which justifies the need for a dental research effort in the Navy.

The general research mission in dentistry is disease-oriented. It seeks, in particular, to impart fundamental information about dental disease on an *a priori* basis. The special biological techniques of physics, chemistry, cell (including microbial) physiology and epidemiology are included in the research. Areas currently being investigated are discussed below.

• *Structure of collagen in periodontium and its chemical nature in health and disease.* Collagen is the organic part of calcified tissues. Its tertiary structure—and possibly secondary and primary structures—may be experimentally altered by inducing a lathyritic or diseased state. Using this state as a model may provide a means of projecting or extrapolating disease states of the periodontium. Also it may be possible to identify that portion of the collagen molecule which produces antibodies—an achievement which would, if completely explained in terms of primary structure, be a significant advance in obtaining host tolerance to heterologous bone transplants.

• *Thermodynamics of hydroxyapatite formation.* Hydroxyapatite is the crystal lattice of tooth enamel, dentin and bone. This program emphasizes the study of the rates of formation of its various stages, and the effects of pertinent ionic species, including calcium and phosphorus, on these stages. It is known that hydroxypatite can be altered by certain ions such as fluoride which form an acid-insoluble compound. However, the kinetics or motions of its formation, especially with regard to intermediate stages such as octacalcium phosphate, are imperfectly understood. An understanding of the effect of ion strength, species and thermodynamic stature could lead to the development of therapeutic measures which would form, biologically, harder tissue crystals.

• *Nature of tin, fluoride, and other ion uptake by tooth enamel.* Special emphasis is being placed on deriving information on the three-dimensional distribution of topically applied ions in enamel. The use of elec-

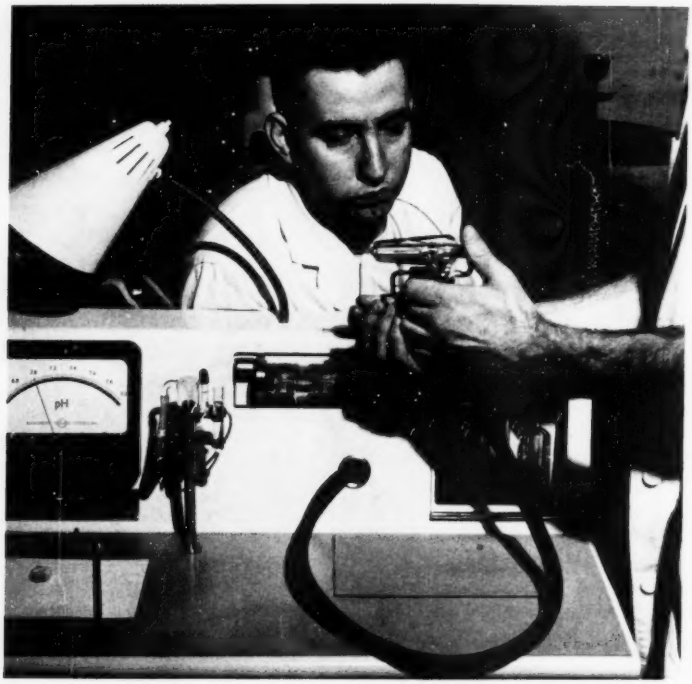


Automatic determination of amino acids in polypeptide chains of dentin collagen and parotid salivary lysozyme

tron probe microanalysis to determine fluorine content, as well as that of accompanying positive ions, is a principal goal.

After bombarding a solid with electrons, x-ray emissions are measured with an electron probe. Spectrographic analysis of these emissions is then made to identify and quantify the range of elements which are unique to the material's composition. Fluorine is not ordinarily included. An interesting advantage of this procedure is the derivation of a three-dimensional distribution pattern of any element throughout the tissue. Present chemical methods, at best, reveal only a two-dimensional distribution of elements in enamel. Research is continuing in an effort to technically include fluorine into the reliable range of the electron probe.

• *Search for chemical trace elements in diets of and genetic markers in caries-free naval recruits and their families.* The objective of this work is, primarily, to identify differences in the electrophoretic distribution of proteins in pure salivary gland secretions; and to determine what elements, other than fluorine, might offer resistance to dental caries. Since 1957, the Naval Dental Research Institute at the Naval Training Center, Great Lakes has studied, up to one-year periods, some 300 naval recruits who



Direct measurement of parotid saliva for pH, bicarbonate and partial pressure of carbon dioxide

had, when entering the service, no dental caries. They are exhaustively studied while in service; however, little is known of a definitive nature about their nutritional or genetic backgrounds.

These studies indicate that both qualitative and quantitative protein content of pure parotid gland secretion is genetically homogeneous. The practical implications of this observation are as yet obscure. Also, these studies have revealed that parts of rural Ohio are the only areas remaining in the United States where the inhabitants subsist solely on indigenous foodstuffs. Therefore, intensive studies have been made of caries-free recruits and their families from those areas—especially if they are non-fluoride caries-free to determine if some element in the soil, vis-a-vis, diet might influence dental health.

• *The role of nutrition,* especially phosphates, in dental caries, and the effect lipid or fat content of teeth has on incidence of dental caries. Undoubtedly phosphates of special chemical nature included in diets do play a role in reducing number of tooth lesions. However, the mechanism of this effect is somewhat obscure, *i.e.,* compared to the degree of understanding regarding fluoride. Current research holds that

the entire diet, particularly in regard to lipids or fatty substances and their incorporation into developing teeth may hold the key to soundness of calcified tissues.

• *Bacterial aspects of dental disease.* This search has revealed the synergistic or cooperative nature of microorganisms in the mouth. Bacteria appear to be a prime factor in causing dental caries and, possibly, periodontal disease. Colonies of bacteria attach themselves to mouth surfaces and acid and/or other toxic materials are produced, causing surface adherents (plaques) to form. Such action indicates that the relationship existing between microbes in the mouth may heavily influence oral disease.

• *Host acceptability of various bony transplants to jaw and facial regions.* Emphasis is being placed on deriving the most suitable heterologous transplant material to hasten hospital or field reconstructive surgery and post-operative recovery.

It has been previously stated that the Medicine and Dentistry Branch program was heavily, although not entirely, oriented toward blood and dental research. A smaller program in tissue transplantation is underway in connection with the Navy Tissue Bank in Bethesda. Here, again, attempts are being made to follow the previously outlined approach of running a multidisciplinary program geared to Navy needs.

The tissue bank is concerned with the freeze preservation of whole organs. In support of this work ONR sponsors research on thermal conductivity and thermal capacity of whole organs, an area in which the tissue bank has no capability. This collaborative arrangement is particularly beneficial, for it brings the contractor directly into contact with the Navy laboratory needing the information.

In addition, a program in freeze-dried skin transplantation, which involves cooperation between several civilian hospitals and the Navy Tissue Bank, is being carried out. Under this program a complete typing of skin donor to the burn patient recipient is being performed, and the data and clinical history of the transplant sent to the Navy Tissue Bank. In the second phase of the study, the Tissue Bank will type freeze-dried skin, provide it to the hospitals and, in turn, receive the clinical data. The study is quite ambitious, in that it intends to do a far more complete tissue typing than that usually performed. It has the advantage of being basic as well as clinical research, it is of Navy interest; and it has the potential of improving treatment of burned patients if effective tissue matching prolongs graft persistence.

The 14th Field Emission Symposium will be held at Georgetown University, Washington, D.C., June 26-30. Additional information on this symposium, which is co-sponsored by ONR, may be obtained from LT Ronald Troutman, ONR Electronics Branch.

262-098 O-67-4

Microbiology-
Through the Kaleidoscope

Robert F. Acker
Head, Microbiology Branch
Office of Naval Research

The Office of Naval Research early recognized the importance of microbiology. Shortly after its establishment in 1946, ONR gave support to the pioneering research studies of germfree animals being conducted by the University of Notre Dame, South Bend, Indiana. This program, begun in 1928, was devoted to the development of germfree techniques and to turning the germfree animal from a scientific curiosity into a useful experimental tool. Today, largely because of the continuing support provided by ONR and other agencies, that dream has become a reality. The germfree animal is being used in laboratories all over the United States and in some foreign countries for research on the causes of dental caries, the physiology of wound healing, immune responses, physiological responses to stress, physical induction of latent viruses, virus etiology of cancer, and nutrition.

Another research program which hearkens back to ONR origins is that dealing with respiratory diseases. Such diseases are an occupational

A throat culture is taken from a Navy recruit. Such tests determine if bacteria, causing respiratory diseases, are present.

hazard of naval recruits, who are often exposed to them under training conditions. Streptococcal infections are of particular concern because, if left untreated, they can develop into rheumatic fever. The latter disease, to which young people are particularly susceptible, is believed to be caused by toxic substances produced by the streptococcus bacterium as it multiplies in the body. These toxic substances are damaging to heart tissue and may cause debilitating injury.

One approach to study on acute respiratory disease has been through the identification of antigens—the material in bacterial cells which stimulates the formation of antibodies in the animal or human body. These antibodies are produced in generous excess, resulting in many more than needed to neutralize the original antigens. Thus, man is not only protected beyond his original convalescence, but may possess an immunity lasting, in some cases, for many years. In cases where the immunity is short-lived, it must be reinforced by "booster" doses of newly administered antigen.

A group of ONR contractors have made long-term studies of specific antigens from the outer layers of streptococcal bacteria. These researchers have separated the antigenic cell walls making up the outer coat and, by using special solvents, have extracted the chemical components in this coat. Finally, they have tested the individual components for antigenicity (ability to induce antibody formation) in experimental animals and for immunogenicity (ability to protect) against a challenge dose of the disease agent. By such means, streptococcus and rheumatic fever specialists have "mapped" the antigens from the streptococcus. They know how many there are, how they differ from one another, and how they render the disease agent capable of invasion and injury. The Navy is better off for these discoveries, because knowledge of the disease agent and its action permits improved prophylaxis, treatment, and control. Antibiotics, in particular, may be more carefully selected and applied for prevention of rheumatic fever in young recruits.

Meningitis

Meningitis is more than a word associated with a disease—it is a term which conjures feelings of helplessness and frustration. And for good reason. Unless controlled, the course of meningococcus meningitis in man may be swift and deadly. It is characterized by rapid onset of chills, fever, headache and stiffness of neck. Within 24 hours, the victim may lose consciousness, experience convulsions, and die. During the height of the disease, the spinal fluid will appear cloudy and be found to contain myriads of pus cells and meningococci.

During World War II cases of meningococcus meningitis responded to sulfonamide drug therapy and later to penicillin. It appeared that

the answer to the threat of meningitis had been found in chemotherapy, but this, unfortunately, has not been the case.

In 1967, meningococcus meningitis poses a new threat, because the causative organism has expressed its genetic license and become "resistant" to penicillin and other antibiotics and to synthetic drugs like sulfa. Because of the prevalence of such drugs in hospitals, clinics, and the bloodstreams of thousands of individual patients, the susceptible meningococci have been killed or inhibited while their genetically resistant relatives have been selected for survival. The entire phenomenon is a simple illustration of the old Darwinian principle of survival of the fittest. In the presence of lethal or inhibitory drugs, Nature selects genetic mutants for survival. The mutant forms may be small in number at first, but, in the presence of the selective drug, they have an ideal environment in which to develop and predominate.

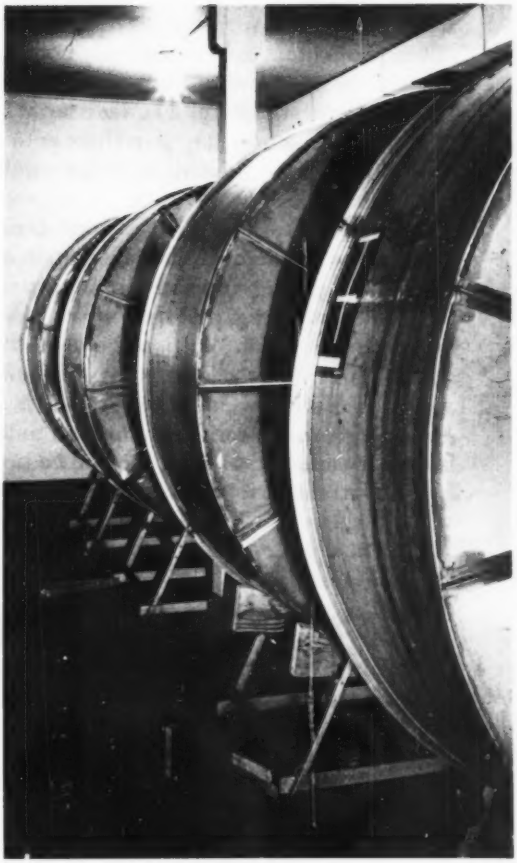
The United States Navy has accepted the challenge provided by meningococcus meningitis and has formulated a specific program for effective treatment and control. The Bureau of Medicine and Surgery, in cooperation with the Office of Naval Research, has formulated a program to control the disease. Much of the work will be concentrated on the development of a vaccine prepared either from cell wall material or from intracellular material. A mucopeptide extracted from intracellular substance is being investigated by a team of scientists at the Naval Biological Laboratory in Oakland, California. Another promising antigen, a polysaccharide derived from cell wall material, has been isolated by a team at the Naval Medical Research Institute in Bethesda, Maryland. Each of these substances, according to preliminary experiments, is antigenic in animals and may immunize man.

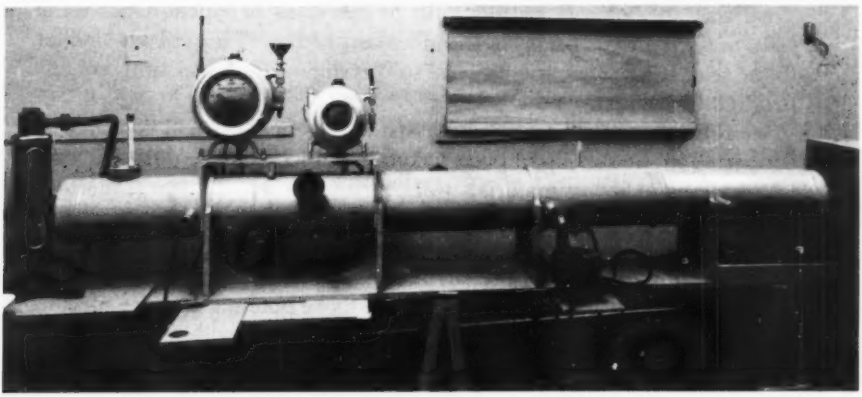
Another line of research is focused upon the selection of a suitable laboratory animal in which to duplicate the symptoms of meningitis as they appear in man. Over the decades of investigation on meningococcus meningitis, no truly satisfactory experimental animal has been found. Animal screening, testing, and selection studies are now underway at the Naval Biological Laboratory, the University of Notre Dame, and at Microbiological Associates, Inc. of Bethesda. It is hoped that satisfactory species and strains of animals will be found not only for mimicking the disease in man, but also for testing the immunogenic potency of potential vaccines.

The Naval Medical Research Unit (NAMRU 4) at Great Lakes, Illinois, is attempting by various drug and antibiotic regimens to control carriers (harborers) of resistant meningococci. Tests show that five to 15% of the recruits are carriers at the beginning of recruit training while 50 to 70% are carriers by the end. Furthermore, the majority of the organisms harbored by these carrier recruits are resistant to sulfa

Research in aerobiology at the Navy Biological Laboratory, Oakland has contributed a great deal to the understanding of the behavior and survival of microorganisms in aerosol form. The Toroid Drums shown at right are used in these studies. Aerosols are released in the drums which are revolving at such a rate that the aerosols remain suspended in the air. In this manner, microorganisms can be maintained in an aerosolized state for study up to two weeks.

The device shown below is called an Aerosol Transport Apparatus. Aerosols released in one end of the tube move towards the other end. This procedure is used to study the effects of various physical and chemical factors on microbial aerosols while the aerosols are in transit.





drugs and penicillin. The big question facing NAMRU scientists is why an individual carrier suddenly becomes a meningitis victim. What triggers the conversion from carrier state to disease state? An epidemiological study currently underway at BuMed's Preventive Medicine Unit, Camp Lejeune may give clues as to how the meningococcus survives, how it is transmitted, and what conditions favor the development of epidemics.

ONR is working on a "combined chemotherapy" approach which involves the simultaneous administration of an antibiotic and a supplemental drug. The antibiotic may be streptomycin or penicillin; the supplementary drug, atabrine, which has been used as a prophylactic to prevent malaria. When combined with an antibiotic, however, it seems to prevent the emergence of antibiotic-resistant bacteria. This approach is effective in the laboratory in preventing resistance among test-tube grown bacteria, and appears to be effective in curing infected laboratory animals. However, it will be necessary to conduct additional carefully controlled experiments to determine its real effectiveness.

Peering into the Crystal Ball

The several broad areas of research described above have brought useful results and probably will pay additional dividends over the next few years. However, it is important to ask where microbiology is going and what the future holds in store.

Techniques and instrumentation are now at hand for a very highly sophisticated examination of the bacterial cell (or virus particle) and its component parts. Laboratory equipment firms in the United States have developed practical devices for growing bacterial cells in liquid nutrient "by the gallon," and for harvesting them literally "by the pound." The moist yeast cake that one could once buy at the grocery store was an example of this kind of cell mass production. Bacterial cells, and even virus particles, though many orders of magnitude smaller than yeast, do lend themselves to prodigious culture and equally prodigious harvest.

Microbial biochemists, biophysicists, and geneticists will continue to cooperate in the solving of bacterial and viral secrets. The ultrastructure of all forms of living materials will continue to be a challenge and will represent a continuing trend. Bits and pieces of cells will be separated, concentrated, purified and identified. Individual antigens will be localized and mapped in the surface architecture of different disease-producing agents. Vaccines will be made more potent and more specific. As purity increases, various antigenic combinations will be tested, until perhaps one day a universal vaccine will render immunity to many commonly encountered diseases.

In this regard, ONR is currently sponsoring investigations of so-called "heterotypic" vaccines. These vaccines are prepared from micro-organisms which make man immune to some diseases and, at the same time, cause different diseases in animals. The classic example of such a heterotypic vaccine is that which is used to prevent smallpox. The vaccine itself, as discovered many years ago by Edward Jenner, is made from a virus which causes cowpox in cattle. It has been shown that human measles virus can produce immunity to distemper in dogs, that bovine diarrhea virus prevents virus-caused cholera in swine, and human adenovirus prevents infectious hepatitis in dogs. These extensions of Edward Jenner's discovery deserve to be exploited and new heterotypic pairs uncovered so that man, again, can benefit from this approach to immunity. Since the instruments are at hand to compare the physical and chemical characteristics of antigenic cellular material, antigenic patterns can now be "matched," and new heterotypic pairs recognized.

ONR has an influential role in the maturation of the science of Marine Microbiology. As the microscopic pieces of the oceanographic environment are carefully studied, their place in the total environmental picture will become better known. Microbiological relationships and associations in the ocean will be better understood, and the multiplicity of individual effects will take their place in the whole of marine biology.

Man's intrusion in the ocean's depths—in diving gear, in submarines, in deep-sea exploration and rescue vehicles, in deep-sea habitats—will play a major role in shaping ONR's program in micro- and macro-biology. Will the problem of acute respiratory disease increase when man spends more time in closed environments? What effect will special breathing mixtures, such as the helium-oxygen mixture employed in Sealab habitats, have on the microbial flora of man, upon his resistance or susceptibility to disease or upon the undersea vehicles and chambers themselves? Will biodeterioration of materials be difficult or easy to control? What will the control measures be? What effect will increased moisture and pressure have upon harmful microbial activities? These are a few of the obvious questions that need to be answered. Two Sealab experiments have been run, and deep sea vehicles like Alvin have proven their value to the Navy. With progress being made at such a pace, microbiologists cannot afford to be complacent. They must recognize the new challenge, and mobilize their wits to meet it.

A Symposium on High Energy Therapy Dosimetry will be held in New York, New York, June 15-17. Additional information on this symposium, which is sponsored by ONR, may be obtained from E. Miner, New York Academy of Sciences, 2 East 63rd St., New York, New York 10021.

Basic Biochemistry to Serve the Navy

Robert K. Jennings
Head, Biochemistry Branch
Office of Naval Research

The first federal agency to have the primary mission of fostering truly basic research was the Office of Naval Research. Its establishment was, in effect, an acknowledgement that the Navy's best interest is served by exploration of the uncharted aspects of nature to see what is there. Such research, in contrast to the type of study needed to solve already recognized problems, is truly basic.

Two decades ago, the academic scientist had only ONR for government support of studies which could not be guaranteed to lead to some desired technological capability. It was true then, as it is today, that the Navy is a vast complex of ships and their engines, of men and their parasites, of communication systems and sewage systems, of offices and homes and hospitals. The problems a city has, the Navy has as well. The welfare and effectiveness of the Navy is not affected solely by gunshot wounds and frost-bite: its efficiency suffers from meningitis and influenza, also. The biochemical problems that civilians face must be faced by the Navy.

It follows that any new biochemical knowledge valuable to the world at large is useful to the Navy. As the only source of government support for basic studies, and with the recognition that what was good for biochemistry was good for the Navy, the Biochemistry Branch began with a program which supported the best scientists and encouraged the most advanced studies in the field.

Today, ONR is one government agency among many offering support for basic research. Some have been established to foster science for the sake of science; others support particular sciences for the advancement of medicine, or of agriculture, or of any one of a number of concerns of the general public as well as the Navy. While there has been no sharp transition point, no announcement of a new mission, the changes twenty years have wrought in the financial substrate of the nation's science have had an inevitable effect on the philosophy of what constitutes basic biochemical research in a naval context. Recognition of the changing times is perceptible in a review of the investigations supported by the Biochemistry Branch over the period of its existence.

As recently as a year ago, the formal description of the program still stated that support was being given to biochemistry, biophysics and toxicology. But examination of the work supported under these three headings shows that as time went on, less investment was being made in studies which would improve the sciences themselves, and more in

studies which sought to explain natural processes which, for one reason or another, were of special concern to the Navy.

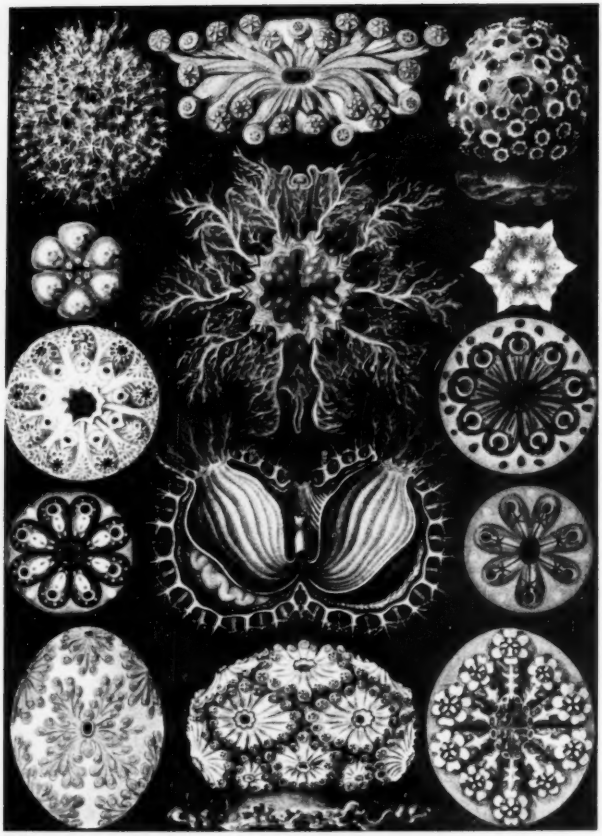
The biochemistry project of recent years was nearly identical to the biophysics project: chemistry is, after all, the expression of forces acting on particles—atoms, molecules and sub-atomic structures. In earlier years, these studies dealt largely with the design of new research tools, with efforts to comprehend the action of enzymes or the relations between molecular structures and physiological functions of substances common to many forms of life. The change is in the nature of a reduction in the support of methodology and the investigation of general principles, and an increase in the application of biochemistry to the exploration of areas of ignorance likely to affect naval operations. The earlier type of program did not, perhaps, promise results more valuable to a sailor than to a civilian. But they did promise results which would be valuable.

The problem in program planning posed by the changing times is a matter of resolving the paradox presented by the fact that appropriate studies should be both basic and naval. If it can be said with assurance that a particular study will yield knowledge necessary to solve a stated naval problem, that study is product-oriented rather than basic. Various Navy Bureaus and Systems Commands have the express mission of dealing with such matters. The Office of Naval Research must continue to explore the unknown to find out what lies therein which might be useful. While product-oriented studies can improve old methods and devise methods for protecting against known hazards and repairing damage, they cannot, except fortuitously, find new alternatives to ships or to surgery, anticipate biological limitations to mechanical marvels, or find an answer *before* an enemy poses a question. The need recognized by the establishment of ONR is a genuine one, and is still very much with us.

But if it is not possible to foresee what will come out of studies supported by ONR, how shall we justify that support as being given for naval research? This question seems to have been answered in the Biochemistry Branch more by intuition than by reason. A parable may help make the nature of the emerging program clear.

In the older program, the Branch sought to help a shivering man by supplying a loom. What the man really needed was a coat, but where there were no tailors and no weavers available, the loom was his first requirement. His real need was for the *fruit* of the loom, and the Navy's need is for the fruit of biochemistry.

First and foremost, the Navy differs from other groups in that its missions are largely concerned with the salty sea. It is important to the Navy to know all there is to be known about that element of our environment. It is naval research to understand wave action. It is just as surely naval



The sea contains a myriad of creatures whose lives are dependent on the very conditions which bar man from the ocean depths

research to seek basic facts of the life contained within and beneath the waves. Without a knowledge of bacteriology, water in a scuttlebutt becomes undrinkable and the best warship might fail in its mission. Without knowledge of nutrition, scurvy could decimate a crew. As the Navy extends its operations to new environments, *e.g.,* man-in-the-sea, biochemical problems will be encountered and will require solution. New knowledge about the chemistry of living as expressed by a marine borer is quite likely to lead to new ways of saving expensive equipment and installations. Marine animals, through their chemistry, daily solve the problems which stand as technical barriers to, and limitations of, naval operations on, in, and under the sea.

What the Navy really wants from biochemistry is the knowledge of how life processes may be manipulated or imitated to its advantage and how Nature does things man would like to be able to do. When these processes are peculiar to the marine environment, the cloth from the loom of biochemistry is certain to have special worth to the Navy.

The emerging program has five facets, some of which still bear the old names but which have a different interpretation on the part of ONR. The five facets are Marine Biochemistry, Metabolic Biochemistry, Immunology, Toxicology, and Toxinology.

Marine Biochemistry

The sea contains an unread library of information which constitutes a proper concern of the basic research investigator. It contains sea creatures whose lives are dependent on the very conditions which bar man from free access to the ocean depths. Life in the sea serves to regulate oxygen and carbon dioxide in the air. It is a storehouse of radiant energy that is of major importance to the world's food chain. There are very likely to be by-products of this life which can serve man well in medical contexts and in the preservation of ships and installations. Basic research on life in the sea and on the effects of sea conditions on the life of man and his parasites are clearly of naval significance.

Metabolic Biochemistry

The earlier concern with such matters as the biochemistry of heredity, serving the Navy only as it serves mankind, has largely been dropped. There remain some areas of general biochemistry which are of particular concern to naval medicine, or other aspects of naval interest. Research *for the Navy* may entail studies made from slightly different points of view than would be provided with support from Public Health or some other agency. Thus, some studies in wound healing, burn syndrome and other aspects of non-marine biochemistry must remain a part of a well-rounded naval program in basic biochemistry.

Immunology

The many implications of the phenomenon of serological specificity—the need for many inoculations to protect against many diseases, the difficulties in tissue and organ transplantation therapy, allergy and auto-immune disease, to name but a few—make this aspect of biochemistry of interest. The ONR program is limited to the investigation of this phenomenon and ancillary studies.

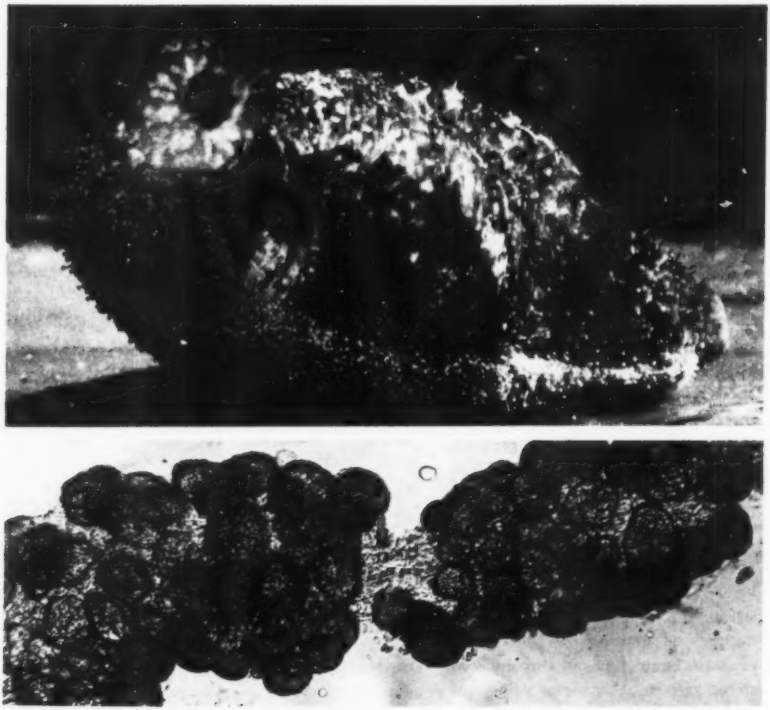
Toxicology

The ONR program in basic toxicology seeks to establish means of measuring and evaluating subclinical chronic toxic responses to materials associated with naval operations, and to recognize the toxicological implications of unusual factors such as pressure, breathing mixtures used at ocean depths, *etc.*, on the pharmacological action of drugs and of materials not usually considered to be poisonous. Such a common drug as aspirin could be a case in point.

Toxinology

The study of toxins produced by animals and plants is enjoying a sudden spurt of activity, probably because of the recent development of new analytical methods and new insights into the chemistry of biological substances. Many marine animals, such as the sea snake and certain jellyfish, present extreme hazards to man and have been little studied in the past. Understanding the physiological effects of such toxins is a promising doorway to the development of new and useful

Certain jellyfish such as this deadly Sea Wasp (Chironex fleckeri) present extreme hazards to man. ONR contractor J. Grassle is collecting specimens in order to investigate its venom. Photograph courtesy Dr. K. Gillett.



Top: The Sea Cucumber, which grows to about 7 in., is another source of toxic chemicals from the sea. Bottom: The Sea Cucumber defends itself by going to pieces—quite literally. A part of the intestines—the Organs of Cuvier—are emitted. In contact with the water, they swell and sticky threads entangle the enemy and release the toxic principle, holothurin. The biochemical aspects of holothurin are under study by ONR contractors. Photograph courtesy Dr. R. F. Nigrelli, New York Aquarium. (Reproduced by permission of the New York Academy of Sciences.)

medical products and devices to regulate such pests and fouling organisms. The biochemical aspects of toxinology, particularly the toxinology of marine life, are becoming a major element in the new Branch program.

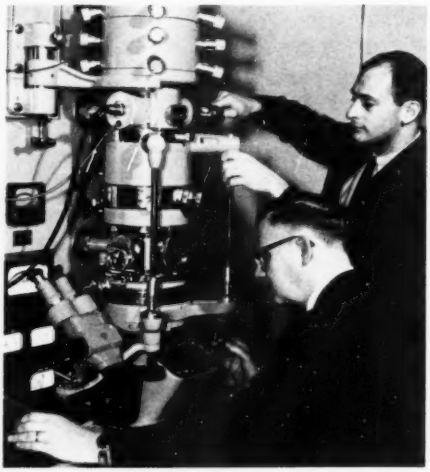
In summary, then, it may be said that the concept of the mission of the Biochemistry Branch has changed from that of offering support for biochemistry and its near relatives to that of supporting such basic research on life processes—particularly marine—as can best be done by biochemical methods. The research suitable for ONR must still be basic and undertaken to find out what lies ahead rather than to answer specific, known questions. But the fields chosen for exploration shall only be those judged promising as a source of knowledge with special naval significance.

Research Notes

NRL Develops Technique to Study Metal Solidification

NRL scientists have developed a technique which permits, for the first time, detailed study of solidification within metals and alloys.

Dr. Martin E. Glicksman and Carl L. Vold of the Metallurgy Division utilize an electron microscope to look through an ultra-thin layer of metal as the metal melts and then solidifies. Metallic materials are not transparent to light over the visible spectrum. Therefore, previous studies using normal optical methods have been limited to observations of solidification at the metal's surface.



Dr. Martin E. Glicksman (right) and Carl L. Vold adjust an electron microscope as they prepare to study solidification processes in metals.

In the NRL technique, the metallic layer is placed in the electron microscope and heated to within a few degrees of melting. A 100-kilovolt electron beam focused through one small area of the metal raises the temperature in this area above the melting point. When the beam is defocused slightly, the temperature is lowered and the melted area resolidifies. Thus, both melting and solidification processes can be observed repeatedly in a single specimen.

After passing through the metal, the electron beam enters the microscope's electron-optic system to form an electron image which, in turn, impinges on a fluorescent screen to create the visible image at magnifications of 10,000 to 30,000 diameters. The electron beam is utilized as both the illumination source and the source of heat for melting, which accounts for the success in achieving the necessary stability for viewing these phenomena at such great magnification.

Utilizing the technique on bismuth metal, the NRL scientists have made the first observations of the formation of microscopic flat faces on metallic crystals during solidification and their subsequent disappearance during melting. These observations give a direct clue to the nature of the fundamental atomic-attachment processes which govern solidification. Observations have been made of solidification in indium, aluminum, tin, and lead, in addition to bismuth and bismuth-lead alloys.

The new technique also makes possible accurate measurement of the boundary between two crystals—the grain boundary—in the area where this boundary intersects the solid-liquid front during solidification. From these measurements, surface energies between metal crystals and their melts, important to metallurgical theory, can be determined.

Grain-boundary melting has also been observed for the first time. This is important in the study of high-temperature mechanical properties, since many alloys of commercial importance fail prematurely because of grain-boundary melting.

New Underwater Research Announced

Employing the deep research vehicle, STAR III, scientists from the U.S. Naval Oceanographic Office will conduct a series of tests aimed at establishing and using an underwater test range.

Tests will consist of a number of precisely positioned points which will provide the framework for the control of a photomapping mission "flown" by a deep research vehicle. The data thus gained will be used to develop the necessary parameters for standardizing an underwater photographic mission. A detailed examination will be conducted for the random and systematic errors caused by the camera system, water-air interface, water density, water clarity, and the uncertainties of navigation.

STAR III is a two-man research vehicle capable of operating at 2000 feet depths with speeds up to 6 knots. The main hull is 5-1/2 feet in diameter, almost 25 feet long and is made of steel. Five viewports are provided, three looking forward and downward, and two at the sides looking slightly upward. A twelve-hour dive is considered normal operating time.

Thermoluminescent Dosimeter Developed at NRL

A new thermoluminescent dosimeter developed at NRL will disclose the effective energy level as well as the amount of x or gamma radiation to which a person has been exposed.

Mr. F. H. Attix, Head, Dosimetry Branch of NRL's Nuclear Physics Division, discussed the device at a Health Physics Society Symposium on Personnel Monitoring Dosimetry held in Chicago recently. Attix and S. G. Gorbics developed the dosimeter which contains two photon detectors in tandem.

Because different types of radiation sources have different energy levels, readings of this dosimeter will help identify the source to which the wearer has been exposed. Since the energy level is related to the radiation's penetrating power, this dosimeter also will allow the approximate determination of the dose (energy absorbed) in vital organs within the body. The photographic film badge is now the most widely used device for personnel radiation monitoring. However, it requires chemical processing to obtain a reading, and is imprecise for gamma ray exposures less than 0.1 roentgen, the maximum average exposure per week permitted for radiation workers. The new dosimeter allows accurate measurements of exposure down to 1/10 of this level. Moreover, it can be reused.

Thermoluminescent dosimeters contain crystalline materials which trap energy from ionizing radiation. When the material is heated, it emits light in proportion to the dose received. The amount of radiation to which it was exposed thus can be determined by measuring the amount of light emitted by a suitable light detector, such as a "photomultiplier" tube.

The dosimeter developed at NRL utilizes the principle that two different thermoluminescent materials—lithium fluoride and calcium fluoride—in a single dosimeter will absorb gamma radiation at different rates, depending on the energy of the rays. When the dosimeter is heated, the light intensity from lithium fluoride measures the radiation exposure, while the ratio of the light intensities emitted from the two materials will give the effective energy level. The two light signals are separated from one another for measurement purposes by a built-in time delay which slows down the heating of the calcium fluoride, a material developed at NRL some time ago by R. J. Ginther. Nevertheless, the total reading process takes less than a minute. The dosimeter may then be used again immediately, although the precision will be improved by heating it first in an oven to "erase" the remaining traces of stored energy.

Attix believes that the new thermoluminescent dosimeter has potential for use in any place where x or gamma radiation monitoring is needed. He points out that while the principle of the dosimeter has been proven, improved designs are still being developed.

High Rate Batteries Achieved

Two NRL scientists have conducted a series of experiments which demonstrate for the first time that use of highly porous active materials in short-life battery electrodes will result in the capacity of the battery to produce an immediate surge of power.

C. M. Shepherd and H. C. Langelan of the Laboratory's Electrochemistry Branch believe that results of the experiments with highly porous materials which they developed and fabricated could lead to improvements in any batteries using porous electrodes. In such applications as rockets, torpedos, missiles and mines, it may be necessary to draw a large amount of power from a battery in a short time. With conventional batteries, however, the capability of delivering a specified amount of power decreases with a decrease in the time taken to draw the power. This decrease in efficiency becomes quite appreciable as the discharge time is shortened from one hour to a few minutes. As the temperature is lowered, the problem becomes greatly aggravated.

Increasing the porosity of the active material in the battery's electrodes increases the battery's efficiency even at short discharge times and at low temperatures. Investigation shows that at porosities of 85 to 90 percent, ampere-hour efficiency of more than 50 percent can be obtained in discharge times of as little as one minute over a range of temperatures extending as low as −60°C. For short discharge times, these electrodes delivered 10 to 30 times more current than the best electrode now available.

NRL Landing Aid Undergoes Evaluation

A new visual landing aid, designed to reduce the landing accident rate of aircraft, has been developed at NRL and is currently undergoing evaluation at Patuxent River Naval Air Station.

This landing aid, called the Altitude Rate Command System, provides highly sensitive rate-of-descent information to approaching aircraft by means of varying light intensities projected from the landing area. The varying light intensities seen by a pilot depend upon the interaction between aircraft motion and beam motion. He thus receives error information without the aid of electrical or mechanical sensors in the aircraft or on the ground and without a data link between the aircraft and the display.

When the pilot sees the light gradually becoming brighter in a cyclic or repetitive manner, he knows his rate of descent is too great and power should be added. When he sees light gradually growing dimmer, he knows his rate of descent is insufficient and power should be reduced. A steady amber light shows that the aircraft is on the glide path with proper rate of descent. In addition to providing rate-of-descent error information, the Altitude Rate Command System indicates whether the aircraft is above or below the glide path. A green light indicates that it is above the path; red, that it is below. Any number of aircraft can utilize the system at the same time.

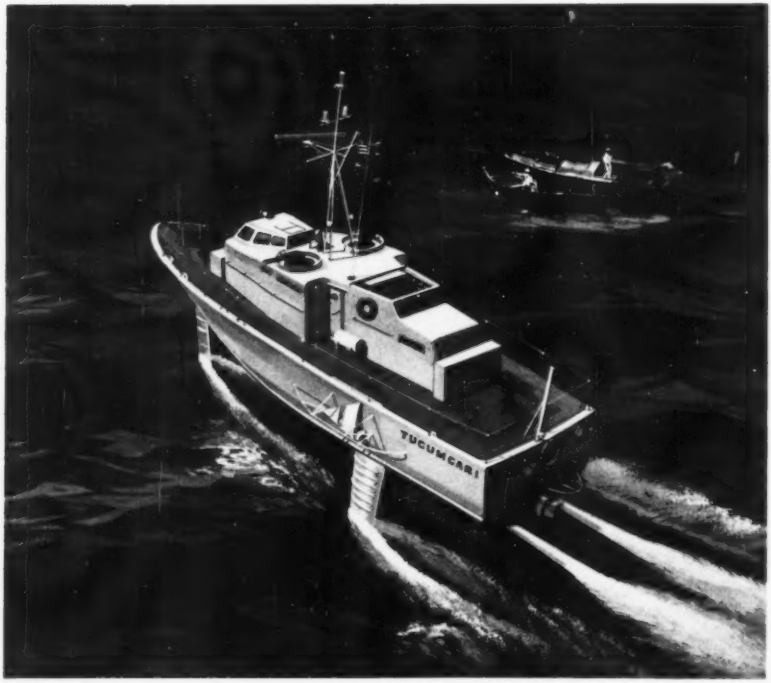
The new landing aid provides several definite advantages over those now used. It gives the pilot an indication of how to correct his rate of descent and has a virtually unlimited range. The basic equipment is relatively simple, consisting of a modified slide projector, a rotating drum on which a patterned transparency is superimposed, and standard condensing and objective lenses. The rotating drum serves as the slide, or object, for projection. Its rotation, together with the pattern superimposed on it, gives rise to the beam pattern moving in space.

Air Survey Unit Completes Experimental Series

An aircraft equipped with meteorological and oceanographic sensors, including an airborne radiation thermometer to record sea surface temperatures, was flown on a series of eight experimental flights in the western North Atlantic. According to the Naval Oceanographic Office, the primary purpose of these flights was a continuation of technical evaluation of air-borne oceanographic instrumentation and its ability to chart in more detail the meandering course of the Gulf Stream.

New Navy Hydrofoil

A hydrofoil gunboat, expected to be capable of speeds in excess of 40 knots, is being built by the Boeing Company for the U.S. Navy Ship Systems Command. The 71-foot hydrofoil will use a water-jet propulsion system and will be the first such craft designed for Navy service. It will be launched in mid-1967. In this jet system, water will be drawn through aft struts into a centrifugal pump and discharged through stern nozzles which are above the water line at high speed. Water-jet propulsion, which has been under test in a research hydrofoil at Boeing for several years, has the advantage of mechanical simplicity and ease of maintenance. The gunboat, which will have fully retractable foils, will be highly maneuverable with rough-water performance and may be the forerunner of a new class of special-mission craft.



NEL Studies the Gray Whale

Marine scientists now have conclusive evidence that gray whales emit unique sounds other than those from locomotion and feeding.

Studies made by scientists from the Navy Electronics Laboratory, San Diego off the San Diego coast in 1966 and 1967 show that gray whales produce distinctive, low frequency, moan-like sounds. These sounds are in the frequency range of 50 to 200 cycles a second, and are about 1.5 seconds in duration. The studies also show that gray whales continue their migration to Mexican waters during nighttime. Previously, many investigators believed that the gray whales did not make sounds as many other whales do, or migrate by night unless there was a full moon so they could see.

The general method of studying the whales was to moor the NEL research yawl SALUDA in a fixed position in the ocean as a platform for both visual and acoustic observations. Hydrophones (underwater microphones) were then put on the ocean bottom, one to the north and one to the south of the ship, 1000 feet apart. The distance between the two hydrophones was carefully measured so that the arrival time differences and the signal strength could be used in calculating the position of the sound source. The studies were aided by a small boat sonar mechanism which was designed to track the whales and corroborate the visual observations.

In tests made in 1966, the moan-like sounds were recorded in limited numbers, but were not positively identified as being generated by the gray whale. Tests made in 1967 positively linked this distinctive sound to the gray whale. Another sound recorded was the "blow" as they surfaced, exhaled and inhaled.

It has been suggested that the gray whale uses his low frequency sound to communicate with other whales. Also, they may be able to obtain information on the location of large objects such as land masses, other whales, the ocean bottom or even nearby ships. Many toothed cetaceans use high frequency clicks for echo-ranging to obtain information about their environment, and it is possible that the gray whales use their low frequency sound in the same manner—but on a much more limited scale.

The tests also showed that whales migrate at night even when there is no moon or when the area is covered by dense fog.

Gray whale migration is often revealed by a spectacular display of bioluminescence. This is caused by the luminescent plankton in the water which light up when disturbed by the whales' swimming movements.

NEL's studies of the gray whale were sparked by the Navy's interest in passive sonar and in the identification of possible strategic targets. They were conducted in mid-January, 1966 and 1967, during the southerly migration of gray whales. A total of 200 gray whales was seen each year during the week-long observations.

Flight Trainer Retires

After more than 20 years of faithful service, the Link "Blue Box" instrument flight trainer is being retired by the U.S. Navy. A victim of advances in the state of the art, the World War II trainer is being replaced by a new basic instrument flight training complex designated 2B21, also a product of General Precision's Link Group.

The basic objective of the 2B21 is to provide instrument training using various radio communication and navigation systems. Flight and engine performance characteristics of each cockpit is patterned after the T-28B, a high-performance, propeller-driven training aircraft. Instructor monitoring facilities of the 2B21 are designed to permit individual as well as group teaching.

On The Naval Research Reserve

Princeton Revisited

Saturday, February 11, 1967, was a bright sunny day in Princeton, New Jersey. It was a far cry from the weather which prevailed on that other Saturday over a year ago when many of the same group of officers and their ladies gathered in the old Nassau Inn to observe the passing of another year.

While NRRC 4-1 can't always select good weather for its annual dinner, it does manage to arrange for the best speaker. RADM John K. Leydon, USN, Chief of Naval Research arrived early at the old Nassau Inn on Palmer Square in historic Princeton town. Later in the evening, following a delicious buffet, Admiral Leydon spoke on the distinguished history and reputation of naval research. RADM Leydon emphasized his conviction that the Naval Research Reserve will grow in strength and in value. This is particularly true in times of national emergency when the Naval Reserve becomes a reserve of manpower that is technically oriented, conversant with the Navy and naval problems, and ready to move forward when needed. Its ranks must not be permitted to shrink as original members reach retirement. Rather, their places must be taken by younger research-oriented officers.

The audience was sorry to hear Admiral Leydon announce his plans to retire from active naval service on June 30, 1967. His other announcement, that CDR Edward C. Reichard, USNR, CO of NRRC 4-1, had just been selected for promotion to the grade of Captain, was happily received.

Research in Space Keynote of NRRC 5-2

Dr. James Eades, Jr., Head of Aerospace Engineering Department at VPI, points out features of VPI Subsonic Wind Tunnel to Dr. Y. Kashiwagi (at right), Prof. A. Jakubowski, and LT W. P. Harrison, USNR-R, CO of NRRC 5-2.

During the current year NRRC 5-2 of Blacksburg, Va. has been afforded an opportunity to venture out into the frontiers of space.

Under the leadership of LT William P. Harrison, Jr., USNR, CO of NRRC 5-2, members have heard speakers from the Department of Aerospace Engineering at the Virginia Polytechnic Institute discuss space developments. Professor A. K. Jakubowski described "The Role of Engineering Research in Poland," Professor Fred H. Lutze explained "Optimum Flight Paths," Professor Yasutada Kashiwagi analyzed "Optimization Applied to Combat Tactics," and Professor James B. Eades, Jr. discussed "Future Space Exploration."

Other research activities discussed have included research involving optimum time-space requirements in production, the economics of mechanization, the mathematics of game theory, the chemistry of atomic species, the command of the written word in industry, and power supplies for space vehicles. Throughout this program, emphasis has been on research involving the application of the imagination, language, psychology, engineering, and mathematics to the problems of tomorrow's space exploration.

NRRC 5-3 Report

Naval Reserve Research Company 5-3, Fort Detrick, Frederick, Maryland has 15 members, most of whom are or have been associated with the Army Biological Laboratories. The greater number of members are engaged in basic research in the field of microbiology. Other fields of interest are medicine, optics and civil construction. The program during the present quarter contains a variety of topics such as "Hydrocarbons in Biological Systems," "Cryogenic Storage," and "Plant Viral Research." To remind members that they are also naval officers as well as scientists and engineers, the following topics will be presented at scheduled drills: "Packaging, Handling and Replenishment at Sea," "Sustained Power at Sea," and "The Administrative Relationship of the Naval Reserve Group and NRRC 5-3."

The commanding officer of NRRC 5-3 is CDR L. Lee Kupferberg, USNR. The Company, which meets 36 times a year, enjoys a close, harmonious and happy relationship with an active U.S. Naval Unit stationed at Fort Detrick. CDR Herbert G. Arm, MSC, USN, the commanding officer of the Naval Unit, recently spoke on some current medical problems he encountered in the Far East, his last duty station.

NRRC 5-4 Baltimore Report

Naval Reserve Research Company 5-4, Baltimore, Md., well along in its second decade of activity, continues as an effective unit of the Naval Reserve with its ranks filled largely by scientists and engineers from industry and universities of the Baltimore metropolitan area. Two recent events of special interest were the national inspection by the Naval Reserve Training Command, Omaha and Company participation in the 1967 Navy Science Cruiser Program. Several members acted as judges of exhibits at the Baltimore Science Fair.

NRRC 5-4 was the Research Company in the Fifth Naval District selected for this year's national inspection by the NRTC Omaha Board. This Board is headed by RADM D. C. Lyndon. Inspection was performed by CAPT H. K. McWilliams, MC, USNR, Assistant for Research Programs, and a member of the Board. The national inspection followed close on the heels of the annual district inspection made earlier by the Group Commander, 5-1(L), CAPT Wm. C. Booze, USNR.

The Company's cooperation with the local science fair dates back to 1959, a few years after the science fair was initiated in Baltimore under the sponsorship of educational and civic groups. The Baltimore Science Fair is held at the

Johns Hopkins University. A principal winner and one alternate are selected for the Navy award at science fairs held throughout the country. The Navy Science Cruiser Program is the Navy's method of stimulating the interest of the youth of America in science. Responsibility for management of the program is vested in the Office of Naval Research, Public Affairs Office.

NRRC 5-8 Inaugurates Joint Meetings

Within the past year a program of joint meetings of the Naval Reserve Research Companies in the Washington area has been inaugurated. Plans are being made to hold joint meetings several times each year. Sponsorship of the meetings will be rotated among NRRCs 5-8, 5-9, and 5-10 which are in the immediate Washington area. Members of Politico-Military Affairs Company 5-1 of Washington, NRRC 5-11 of Annapolis, Maryland and NRRC 5-12 of Dahlgren, Virginia will also attend the joint sessions.

The first joint meeting was held in the Department of the Interior auditorium on September 15, 1966 with RADM John K. Leydon, USN, Chief of Naval Research as the featured speaker. Over 300 reserve officers were present to hear Admiral Leydon's stimulating discussion of naval research goals. The second joint meeting is scheduled to be held on June 6, 1967. Participants in the ONR Seminar which will be in session at that time will be able to attend.

The purpose of the joint sessions is to provide an opportunity for the participants to hear a speaker of outstanding reputation and ability who might not be available to speak to an individual Research Company. In addition, the meetings provide an environment wherein members of the various Research Companies can discuss problems of joint interest. The sharing of experiences among the large number of reservists should prove to be of real value.

Project Management Subject for NRRC 5-9

Naval Reserve Research Company 5-9, which meets at NRL, has planned a most interesting fourth quarter drill schedule. A series of lectures planned for the next three months will afford member reservists an excellent opportunity to become better informed on the functions, organizations, and operations of the Project Managers in the Navy Department.

This series was initiated on April 7 by a general discussion of Project Managers from the functional and organizational viewpoint, followed by an in-depth discussion by six outstanding speakers representing six different projects. The series will conclude on June 16 with a presentation by RADM Nathan Sonenshein, USN, Project Manager of "Fast Deployment Logistics Ship Project."

CAPT George F. Williams, Former CO of NRRC 5-10, Retires

Captain George F. Williams, MC, USN, former commanding officer of NRRC 5-10, recently retired from the Navy after 30 years of service. Some of the

highlights of his career include directing the medical operations of the amphibious landings during the New Guinea and Philippine Campaigns, and serving as Special Liaison Assistant to LTGEN J. R. Hodge, Commanding General, Allied Occupation Forces, Korea. During the latter assignment, he arranged for the return of Dr. Syngman Rhee to Korea.

Captain Williams helped organize NRRC 5-5 at Richmond in 1950. After transferring to the National Institutes of Health, Bethesda in 1953, he joined NRRC 5-10 and has been active in naval medical research and reserve programs since that time. He served as executive officer and commanding officer of 5-10 in 1959 and 1960, respectively. Also, he organized and conducted the medical studies of the Fallout Shelter Trial held during the Research Reserve Seminar of May 1963.

Program Resources Available at NRRC 5-11

The location of NRRC 5-11, Annapolis, Maryland, is unique when considering program resources. This company can draw upon academic, government,

Guests from ONR and COM5 hear lecture on captured air bubble vehicles. Left to right: CAPT W. E. McConnaughey, CO, NRRC 5-11; LT W. B. Greene, Specialist Program Officer, COM5; CDR E. F. Kehoe, ONR, 5ND and 6ND Research Reserve Liaison Officer; and Mr. M. W. Beardsley, speaker.

and industrial talent in the Washington-Baltimore area, and tap the resources in the U.S. Naval Academy and the U.S. Naval Ship Research and Development Center in the Annapolis area.

The educational centers, federal agencies, and industrial complexes in the Washington-Baltimore-Annapolis triangle have a plentiful supply of diverse research expertise. As a result, NRRC 5-11 has had the advantage of a wide variety of unclassified presentations in areas such as work-study techniques in ship design, captured air bubble vehicles, Vietnam, the new astronomy, USS SAVANNAH, small craft armament, statistical design of experiments, hydroballistics, bioacoustics, and the UFO. Classified presentations on various topics have also been held.

In addition to its excellent program resources, NRRC 5-11 was fortunate enough to have several well qualified members of Composite Company 5-42 join last year, bringing the strength of NRRC 5-11 to 27 officers.

NRRC 5-12 Conducts Program on Air-Ocean Environment

During the last half of FY 1966, NRRC 5-12 members discussed the possibility of conducting a comprehensive program in a specific area rather than the usual individual programs in many subject areas. On the basis of information provided by a member who had performed training duty at the U.S. Naval Academy, it was decided to concentrate on a program in Air-Ocean Environment for the entire year.

Assistance in developing the program was obtained from the Naval Science Department of the Naval Academy who provided a curriculum outline of the Air-Ocean Environment Course offered at the Naval Academy, advice on reference material, and a listing of training aids available. From this material, a program was adapted and approved by the Office of Naval Research.

The Air-Ocean Environment program commenced in July 1966 with the Head of the Naval Science Department, U.S. Naval Academy making the first presentation. Subsequent presentations were made by representatives of the Navy Oceanographic Office, the Fleet Numerical Weather Facility, the Office of Naval Weather Service and the Executive Secretary, Inter-Departmental Committee on Atmospheric Sciences. During the remainder of the program year, presentations will be made by representatives of the Environmental Science Services Administration, the National Aeronautics and Space Administration, and the Joint Metrological Satellites Program Office.

A complete evaluation of the program cannot be made until it is completed. However, some pertinent observations can be made on its effectiveness at the present time. Perhaps the most important is that the entire year's program can be planned in advance. Also, concentrating the program in one specific area provides for more detailed information, and a direct relationship exists between succeeding presentations.

Staff Corps Promotion Selections

Ten members of the Research Reserve were included on the selection list for Staff Corps officers prepared by the FY 1967 Reserve Selection Board. Five Research Reservists were selected for promotion to Captain and five to Commander. Congratulations to:

	NRRC
Captain, Medical Corps	
Walker, Duard L.	9-14
Captain, Supply Corps	
Anderson, Edward E.	1-1
Hartman, Don A.	8-8
Lemay, J. W., Jr.	8-8
Captain, Civil Engineer Corps	
Hammer, John G.	11-11

	NRRC
Commander, Medical Service Corps	
Brownson, Robert H.	12-5
Schwartz, Marvin	4-11
Seale, Leonard M.	3-3
Thomas, Walter D., Jr.	12-5
Commander, Supply Corps	
Snipes, Wilson C.	5-2

Random Noise

Dr. John A. Nagay has been designated, effective March 23, as Head of ONR's Group Psychology Branch. He relieves Dr. L. Petrullo who has been Acting Head concurrent with his responsibilities as Director, Psychological Sciences Division.

Dr. James H. Schulman, Acting Associate Director of Research for General Sciences at NRL, has been nominated to the Steering Committee of the Solid State Sciences Panel of the National Academy of Sciences-National Research Council.

Mr. William Mollering has been appointed assistant to the technical director of the Navy Electronics Laboratory, San Diego. His duties at NEL will consist of developing and coordinating technical work plans and acting as an advisor to Laboratory management.

Dr. Herbert V. Weiss, a chemist at the Naval Radiological Defense Laboratory, San Francisco, has developed a technique to isolate a fission product element in 0.5 second. Application of Dr. Weiss' technique has led to the identification of two short-lived isotopes, silver-118 and palladium-118.

Dr. Allen H. Schooley has been designated Senior Research Scientist of NRL's Ocean Sciences and Engineering Division. Dr. Schooley has been a member of the NRL staff since 1940 and is well known for his experimental work on phenomena near the sea-air interface.

To give credit where credit is due, we would like to correct an error that appeared in the February issue. The article about the federal ocean buoy system study indicated that the NOMAD buoy system was developed by the Naval *Ordnance* Systems Command (formerly part of Bureau of Naval Weapons) in cooperation with the Bureau of Standards. The system was actually developed by the Naval *Air* Systems Command (formerly part of BuWeps) in cooperation with NBS.

Selected Contract Research Reports

The contract research reports listed below have been extracted from Technical Abstract Bulletins 67-5 and 67-6 of March 1 and 15, 1967. Government agencies and their contractors who are registered with the Defense Documentation Center of the Defense Supply Agency may obtain *free* copies from the Center at Cameron Station, Alexandria, Virginia 22314. Abstracts of the reports are found in TABs 67-5 and 67-6.

For non-DDC users, most reports may be purchased from the Clearinghouse for Federal Scientific and Technical Information, Department of Commerce, Springfield, Virginia 22151.

AERONAUTICS

Final Technical Report, Janair Contract 4429 (00); Bell Helicopter Co., Fort Worth, Texas; Dougherty; AD-645 492

ASTRONOMY AND ASTROPHYSICS

Astrophysical Research Papers; Calif. U., Berkeley; Spinard; AD-645 279

The Evolution of an H II Region During the Formation of the Exciting Star; Chicago U., Ill.; Vandervoort; AD-645 291

Solar Source of the Interplanetary Sector Structure; Calif. U., Berkeley; Wilcox and Ness; AD-645 458

Some Effects of the Strong Interactions on the Properties of Neutron-Star Matter; Cal. Tech., Pasadena; Wolf; AD-645 486

Positions for 3C Revised Radio Sources; Cal. Tech., Pasadena; Fomalont *et al.;* AD-645 526

Primordial Helium Abundance and the Primordial Fireball; Princeton U., N.J.; Peebles; AD-645 527

A Catalog of the East-West Visibility Functions of Radio Sources at 1425 MHz; Cal. Tech., Pasadena; Fomalont; AD-645 528

ATMOSPHERIC SCIENCES

Visibility and Small-Ion Density; Litton Systems Inc., Minneapolis, Minn.; Ruhnke; AD-645 502

The Mechanisms of Stepped and Dart Leaders in Cloud-to-Ground Lightning Strokes; Calif. U., Berkeley; Loeb; AD-646 128

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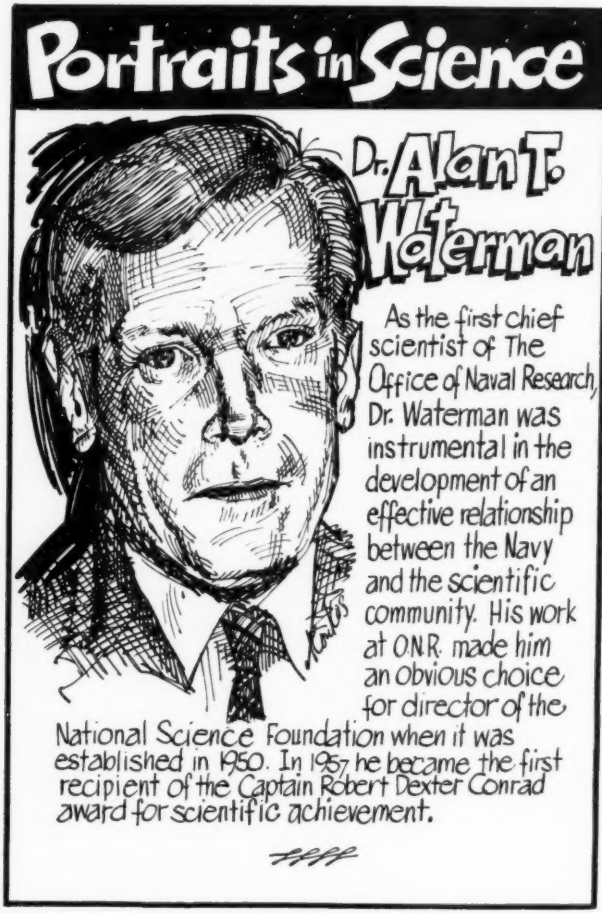
Portraits in Science
Dr. Alan T. Waterman
As the first chief scientist of The Office of Naval Research, Dr. Waterman was instrumental in the development of an effective relationship between the Navy and the scientific community. His work at O.N.R. made him an obvious choice for director of the National Science Foundation when it was established in 1950. In 1957 he became the first recipient of the Captain Robert Dexter Conrad award for scientific achievement.

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Two NRL Employees Receive Meritorious Civilian Service Awards

Two NRL employees recently received the Meritorious Civilian Service Award, one of the highest awards granted to civilians by the Secretary of the Navy. The awards were presented by CAPT T. B. Owen, Laboratory Director, on March 17, 1967.

Dr. Louis F. Drummeter, Jr., acting Superintendent of the Optical Physics Division received his award for significant contributions to the field of atmospheric optics and the physics of the atmosphere.

Dr. Louis F. Drummeter, Jr.

Dr. Drummeter is an authority on optical coatings of space vehicles, a pioneer in the development of infrared methods to detect aircraft and missiles, and an expert in the application of laser technology to the military. He is credited with the development of a spectra of air fluorescence excited by x-rays from nuclear bombs, a phenomenon which is the basis for a leading method for optical detection of high altitude nuclear explosions.

George E. Pulman, a plumber in the Laboratory's Public Works Division, was honored for his act of heroism last August 2 when he disregarded his personal safety to avert a potentially dangerous situation. By closing a cylinder valve from which ignited gas was escaping, he extinguished the fire which had threatened to spread to 59 adjacent hydrogen cylinders. At the time, Pulman was suffering from burns incurred when his clothing was set on fire by the escaping gas.

George E. Pulman (left) shows Public Works Officer LCDR S. D. Lowe how the fire was averted.

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The Biological Sciences

The Navy's interest in biology has increased as biology's importance to naval operations has increased. The objectives of ONR's Biological Sciences Division therefore are to maintain personnel in the best possible condition to effectively perform their missions, to prevent machines and equipment from becoming inoperative through activities of biological systems, and to learn how various biological systems can be utilized to help solve Navy problems.

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NAVSO P-510

Biological deterioration must be dealt with in any activity involving the installation of equipment in the sea. The annual cost to the Navy to replace pilings and other underwater and waterfront structures, to clean ships and other equipment, and to provide temporary protective measures is extremely high.